Section 5: Hazard Identification and Vulnerability Analysis (HIVA)

2009 Plan Review Crosswalk, Sections 5-7

This introduction section has been significantly enhanced in 2009. All Section 5 elements of the 2004 Plan have retained its integrity in the 2009 Plan. Updates to documented FEMA declarations, other significant hazard incidents and hazard history have been updated and included from years 2004 – September 2009. All footnotes have been reviewed and updated as needed or possible.

Section 5 identifies and profiles hazards with assessment of vulnerability in terms of probability and potential hazard vulnerability, or impact in King County. When King County is referenced it also includes King County Government, its unincorporated areas, and all of its jurisdictions and special purpose districts which are part of this Plan.

Hazard Identification

The first step toward a mitigation program is the identification of the hazards a community may face. First hand information can be obtained from interviews of businesses, local employees, first responders, and residents; or gathered from newspaper archives, National Weather Service, FEMA documents, state and local government records, and the Internet. Largely, local hazards can be categorized as either natural or technological/manmade events. While the local climate changes rather slowly, our manmade environment can change rapidly, especially in terms of the local economic base.

Profiles of Hazards (Update for 2009)

To make the hazard analysis more helpful, adjective descriptors (high, moderate, and low) are established for each hazard's probability of occurrence and the county's vulnerability, or impact, in the event of a hazard. The risk rating is assigned on the probability of a hazard occurring at intervals, as mentioned above. A final risk rating is assigned based on a subjective estimate of their combination, and the risk rating will ultimately help focus the emergency management and hazard mitigation programs on the incidents with the greatest potential risk.

Some hazard incidents occur on an almost annual basis while others may not happen once within our lifetime. Additionally, not every hazardous incident or event occurs with notable damage or loss of life. For this reason, hazards are assessed by comparing the experienced frequency and probability of the event and the potential vulnerability / impact that may result.

High Probability Low Impact	**High Probability Moderate Impact**	**High Probability High Impact**
Moderate Probability Low Impact	**Moderate Probability Moderate Impact**	**Moderate Probability High Impact**
Low Probability Low Impact	**Low Probability Moderate Impact**	**Low Probability High Impact**

Probability and Hazard Impact

The 2004 Plan wording: probability vs. hazard impact, has been changed to: probability *and* hazard impact, in the 2009 Plan.

Planning begins with events that are expected to occur often and have potentially high impacts on life and property followed by those with more moderate or low probabilities or moderate or low impacts. Jurisdictional strategies are dependant on the philosophy and experiences of local officials. Largely, the priorities addressed in the HIVA identified hazard development. Updates or expansions are a reflection of this assessment and local philosophical priorities.

For the purpose of this document, the criteria for high, moderate, and low probability are:

High Probability: once a year
Moderate Probability: once every two to ten years
Low Probability: once every ten to fifty years

Events occurring once every 50 to 1,000 years will are treated as “low probability” for the purpose of this document.

Cause and Impact Effect

Disaster incidents can be categorized as the cause of an impact or the effect/impact itself, or caused by a secondary hazard contributing to the disaster incident. Winter storms bring heavy rains, high winds, snow, and cold temperatures (causes) that may result in property damage, local flooding, power outages, injuries and deaths (effects). Earthquakes can also bring landslides (lahars), fire hazards, hazardous materials spills or releases. Despite flooding being an effect of severe weather conditions, it can also be considered to be an event with its own unique effects to roadways, structures, building sites, hazardous materials spills and releases, and bridges. Power outages can be associated with a variety of natural or manmade events. Power interruptions are addressed as effects of both natural and technological (man-made)

incidents in the King County Regional Hazard Mitigation Plan (RHMP). Washington State Emergency Management has included nine FEMA identified natural hazards in the 2008 State Hazard Mitigation Plan. The King County RHMP will follow that model for the 2009 Plan update to include eight out of nine natural hazards, and include additional natural and technological, or manmade, hazards.

Understanding Risk Ratings, Terminology Defined (*new for 2009*)

High Risk Rating: warrants major program effort to prepare for, respond to, recover from, and mitigate against the hazard. A high risk rating for a hazard means that the hazard has a high probability of occurrence and possibly a significant and larger portion of the population is vulnerable to the hazard.

Moderate Risk Rating: warrants moderate program effort to prepare for, respond to recover from, and mitigate against the hazard. A moderate risk rating for a hazard means that a hazard has a moderate probability of occurrence, and only a part of the population is vulnerable to the hazard.

Low Risk Rating: warrants more modest program effort to prepare for, respond to, recover from, or mitigate against the hazard beyond general awareness, training, and exercises. A low risk rating means that for a hazard means that the hazard has a low probability of occurrence, and a smaller segment of the population is vulnerable to the hazard.

Probability of Occurrence: An adjective (high, medium, low) of a hazard impacting King County within the next year, two to ten years, or every ten to 50 years, respectively. Probability is based on a limited objective appraisal of a hazard's frequency using information provided by relevant sources observations and trends.

High Probability: there is a great likelihood that a hazardous event will occur within the next year.

Moderate Probability: there is a moderate likelihood that a hazardous event will occur within the next two to ten years.

Low Probability: there is a lower likelihood that a hazardous event will occur within the next ten to fifty years.

Vulnerability / **Impact** : An adjective description (high, moderate, low) of the potential impact a hazard could have on King County. It is the ratio of population, property, commerce, infrastructure and services at risk, relative to the entire city. Vulnerability is an estimate generally based on a hazard's characteristics.

Summary of Results (new for 2009)
The following table is a summary of the results for all the hazards that are evaluated in this document, as indicated.

Recap in 2009 of Summary of Results Table of RHMP 2004

Hazard	Hazard Risk Severity + Location Frequency/Probability	Vulnerability Assessment Risk Natural + Manmade Impact	Total Risk Hazard Probability+ Vulnerability Impact (not captured in 2004)
Severe Weather	High	Moderate	
Avalanche	Low	Moderate	
Flooding	High	Moderate	
Landslide	Moderate	High	
Earthquake	Moderate	High	
Civil Disorder	Moderate	High	
Terrorism	Moderate	High	
Drought	Moderate	Moderate	
Fire Hazards	Moderate	Low	
Hazards Materials/ Release	High	Moderate	
Transportation	Low	High	
Tsunami & Seiches	Low	Moderate	
Cyberterrorism	Moderate	Moderate	

2009 Summary of Results Table (new in 2009)

****BOLD HIGH: Indicates Vulnerability Risk update from 2004 RHMP**

Hazard (In new 2009 ranked order of Total Risk)	Hazard Risk Profile Severity + Location Frequency/Probability	Vulnerability Risk Natural + Manmade Impact	Total Risk Hazard Probability+ Vulnerability Impact (new in 2009)
**Severe Weather	High	Moderate	High
Flooding	High	****HIGH**	High
Earthquake	Moderate	High	High

**Landslide	Moderate	High	High
**Hazards Materials/ Release	High	Moderate	Moderate
**Fire Hazards	Moderate	Low	Moderate
**Transportation System	Low	High	Moderate
Drought	Moderate	Moderate	Moderate
Terrorism	Moderate	High	Moderate
Civil Disorder	Moderate	High	Moderate
Avalanche	Low	Moderate	Moderate
Tsunami & Seiches	Low	Moderate	Moderate
Cyberterrorism	Moderate	Moderate	Moderate
NEW in 2009			
Dams / Dam Safety	Moderate	High	High

Note: **The 2009 Flooding hazard vulnerability, or impact, has been upgraded to high/high, from high/moderate in 2004 because of the increased Green River Valley risk of potential flooding in the next three to five year period starting 2009 and beyond. **If severe weather contributes to a flooding incident(s), these additional hazard rankings may be suddenly upgraded because flooding impacts increases the risk of possible increased frequency of secondary hazards such as landslide, hazardous material spills or releases, fire hazards, and transportation system impacts.**

Five Year Plan Cycle

Hazard mitigation planning is based on a five year planning cycle. Research and planning for all the hazards a community may be vulnerable to is a time-consuming process. For this reason, the 2004 RHMP contained only certain identified hazards and other additional identified hazards are included in the 2009 RHMP. This five year time period also includes a process to continually review HIVA documents in order to maintain current hazard information and to accurately evaluate vulnerabilities and planning priorities.

The Pacific Northwest has experienced specific notable natural hazards listed below for thousands of years. These hazards were included in the 2004 RHMP. The topics listed below were identified as a higher priority based on past hazard history, frequency and likelihood of occurrences, and potential catastrophic losses. On the strength of recent national and local incidents and other concurrent planning processes, it seemed logical to add terrorism and civil disorder (unrest) to the first RHMP 2004 and HIVA focus.

The following hazards were addressed as priority as part of the first 2004 RHMP planning cycle:

Severe Weather
Avalanche
Flooding
Landslide
Earthquake
Civil Disorder (unrest)
Terrorism

The 2004 RHMP also included expansion and further development of other identified hazard topics including:

Drought
Fire Hazards
Hazardous Materials
Transportation
Tsunami / Seiche
Cyberterrorism

Any new data regarding these hazards has been incorporated into their respective sections for this 2009 update, especially flooding hazards, which has a higher risk rating in vulnerability and total risk. Flooding hazard is the priority for 2009 and beyond due to the Howard Hanson Dam situational awareness and potential Green River Valley flooding increased risk. The 2009 RHMP will include pertinent updates to the above mentioned hazards as they apply and incident dates will be added to the respective tables from 2004 onward.

Development of an important identified emerging hazard topic for 2009 RHMP is based on a change of priority of hazard probability and potential impact, new current situational awareness and the FEMA Hazard Mitigation Plan guidance. The identified technological hazard that addresses new and emerging conditions is:

Dam / Dam Safety

The 2004 RHMP initially identified very specific separate hazards that were either subsets of other identified hazards or too narrow in focus to be developed towards incorporation into the current 2009 RHMP. Examples from 2004 are industrial, erosion, urban economy, agricultural economy, air and water quality, and food contamination. These topics will not be included as a separate title in the 2009 RHMP. They may, however, be mentioned and referenced in the documentation of the other listed hazards if impacted by those elements.

Future hazard topics are identified for the next RHMP planning iteration to be incorporated into the Plan, two natural and two technological, or manmade, are:

Pandemics (Epidemics)
Volcanoes / Volcanic activities
Extreme Heat
Pipeline (Utility Energy Shortage)

Sources of Data

Information supporting the hazard identification and vulnerability assessment update for the 2009 Regional Hazard Mitigation Plan (RHMP) was obtained from a variety of sources (this is an expanded list from 2004):

- King County Office of Emergency Management - Duty Officer Log Activations 1996 to present
- Presidential Disaster Declarations 1990 to present
- Review of past incidents and declared disasters
- Media, Newspapers and Internet Website searches
- Jurisdiction and agency experience and documentation
- Special reports, papers, or new projects
- King County Geographic Information System (GIS)
- King County Department of Natural Resources and Parks (DNRP)
- King County's Flood Control Center and Flood Control District data
- University of Washington Seismology Department
- Seattle King County Public Health (PHSKC)
- Review of the State HMP and other State Plans
- WA Department of Natural Resources, WA Geological Survey
- National Weather Service (NWS)
- Federal Emergency Management Agency (FEMA) website
- FEMA Risk Analysis HAZUS HM runs completed for Howard Hanson Dam
- U. S. Army Corps of Engineers (USACE) reports
- Other local or county department plans

Several substantive changes made for 2009

Introduction

With a substantial marine influence, the climate of King County is well known for its moderation. Despite this, severe weather in King County can happen at any time of year but usually occurs between October and April but can occur in summer months. Severe weather can include unseasonable rain, snow, ice, extreme cold, and high winds. (Wind speed itself does not predict damage due to different tempering effects of variable landscapes; 45 mph tends to be the threshold at which damages occur.)

The effects of severe weather in the County can include flooding, power outages, land and mudslides, and road, rail and airport closures. There is little snow removal equipment or budget associated for such service in King County. Vehicles and drivers are often poorly equipped to travel roadways under such conditions. For this reason, impacts from unusually heavy snowfalls and severe winter tend to be dramatic though short-lived, and typically occurs annually.

High Probability Low Impact	**High Probability Moderate Impact**	**High Probability High Impact**
Moderate Probability Low Impact	**Moderate Probability Moderate Impact**	**Moderate Probability High Impact**
Low Probability Low Impact	**Low Probability Moderate Impact**	**Low Probability High Impact**

Severe Weather Probability and Severe Weather Impacts

Hazard Identification

Precipitation

The geographical location of northwestern Washington subjects it to several climatic controls: the effects of terrain, the Pacific Ocean, and semi-permanent high and low pressure regions located over the North Pacific Ocean combine to produce significantly different weather conditions within short distances.[1] Accordingly, rainfall in King County varies widely from city to city and area to area. The City of Seattle has an average of 37 inches annually;[2,3] while Enumclaw has an annual average of 55 inches[4,5] and Snoqualmie/North Bend has 61 inches[6,7] of precipitation. The majority of this precipitation occurs as rain in the lowlands between October and early May with substantial snow packs in the Cascades during the same time frames.

Snow accumulations in King County at elevations below 2,000 feet are uncommon. On average, Seattle will have one or two snow storms during a winter season with appreciable accumulations. Snow accumulation rarely remains two days after such a storm. Heavy local snows and associated cold conditions have resulted in power outages, transportation restrictions, and adverse impacts to the regional economy.

Table 5-1: Precipitation in Inches by Month[8,9]
(Snow and Rain for Seattle)

Month	Average Snowfall[8]	Average Snow Pack[8]	Average Rainfall[8]	Average Precipitation 07-08 / 06-09[9]
July	0	0	.76	0.77
August	0	0	1.10	0.87
September	0	0	1.72	0.78
October	0	0	3.44	2.17
November	0.9	0	6.10	6.52
December	1.8	0	5.86	4.10
January	12.0	0	5.76	5.40
February	1.7	0	3.97	1.47
March	1.4	0	3.73	4.16
April	0.1	0	2.51	3.36
May	0	0	1.69	3.61
June	0	0	1.45	0.18

Wind

High wind events in King County are fairly common and are usually experienced as part of a winter weather pattern.

*Tornado – (*new in 2009)

Though rare, King County and the sound region does experience tornado activity. Tornados have reached F3 designation within the region, but the slower F0 and F1 class tornados are more common. In September of 2009 the Enumclaw area experienced a class F1 tornado. Though wind speeds of up to 110 mph were estimated, the most substantive damage recorded was the uprooting of trees and damage to roofs, much of which could be attributed to the preceding storm[13]. Tornados are a result of strong weather systems and often times accompany serve wind, rain, and hail.

Ice and Extreme Cold

King County's marine climate results in very few extreme cold/ice events. Typically, the area experiences below freezing temperatures for 10-14 consecutive days in January or February.

Flooding

Severe weather is often accompanied by heavy rains and flooding conditions, See "Flooding" section.

Power Outages

Power outages are commonly experienced in association with high winds, rain and flooding conditions.

History of Events

The table below represents damages to public property from severe weather events since 1972. Damages occurred to roadway, school roofs, reservoirs, vehicles (from falling trees), and public buildings were caused directly or indirectly by wind, rain, snow load, or flying debris.

Table 5-2: Severe Weather History

FEMA No.	Dates	KC Public Damages (FEMA Approved)
328	1972 – Flooding	Prior to FEMA
492	1975 - Flooding	Prior to FEMA
545	1977 – Flooding, landslide	Prior to FEMA
612	1979 – Flooding	Figures not available
757	1986 – Flooding, landslide	Figures not available
784	1986 – Flooding	Figures not available
852	1990, Jan – Flooding	$5,246,411
883	1990, Nov – Flooding	$3,694,824
896	1990, Dec – Flooding	$ 477,737
981	1993, Jan – Inaugural Day Wind Storm	$1,927,837
1079	1996, Jan – Winter Storm	$3,031,519
1100	1996, Feb - Flooding	$4,226,719
1159	1997, Jan – Winter Storm	$3,576,309
1172	1997, April – Flooding	$1,266,446
1499	2003, Nov – Flooding	$4,400,000*
1671	2006, Nov – Flooding	$16,000,000*
1682	2006, Dec – Wind Storm	$29,000,000*
1734	2007, Dec -- Winter Storm	$72,500,000*

1817	2009, Jan – Winter Storm	$17,000,000*
1825	2009, Mar – Winter Storm	$5,500,000*
		**estimate*
2009 Total		**$167,847,802**

Hazard Impacts

Precipitation

Heavy local snows and associated cold conditions have resulted in power outages, transportation restrictions, and adverse impacts to the regional economy.

Wind

Winds in excess of 45 miles per hour can cause road closures, significant damages to public and private property, and injuries to public safety, utility workers and private citizens. One of the best known of these was the Inaugural Day Windstorm on January 19, 1993.[10] Winds began mid-morning, lasted five hours and reached over 90 miles per hour in downtown Seattle. The Hanukkah Eve Windstorm of December 15, 2006 heavily damaged the Seattle area power grid, affecting hundreds of thousands in the subsequent weeks.[12] Widespread power outages resulted from downed trees and many suburban and rural roads were made impassible. Usually, these winds are from the south.

Ice and Extreme Cold

Extended temperatures of less than 20 degrees can burst residential water pipes. The population is vulnerable to the effects of extreme cold and associated power outages. In some cases, shelters are opened for the homeless, senior citizens and people without heat/power.

Power Outages

Downed trees caused by high winds and rain saturated soils damaged transmission lines and cause power outages in local areas for hours to days when multiple occurrences are experienced. Utility crews from Puget Sound Energy, Bonneville Power and Seattle City Light work around the clock to restore services. The Inaugural Day Windstorm left 750,000 customers without power.[11] The Hanukkah Eve Windstorm winds and subsequent heavy rains cut electricity to more than 1.8 million customers, hundreds of thousand remained without power for days.[12] Downed power lines pose an electrocution hazard to motorist, pedestrians and any unsuspecting by-standers.

Transportation Impacts

High winds sometimes result in the closure of the floating bridges (Highway 520 and Interstate 90) over Lake Washington, although rare. Wind-driven waves often break over the roadway under those conditions.

Trees uprooted by wind regularly sever power lines and/or block vehicular access. Together, these conditions make roadways impassable.

Past Mitigation Efforts

One of the most common impacts from severe weather is the loss of commercial power. Since many other services rely on power for critical functions, providing contingency backup power capabilities has long been a favored strategy for mitigating damages from winter storms. Many more police precincts, fire stations, emergency operations centers, hospitals, information technology data centers, service providers and major employers have already introduced this capability.

Severe Weather Endnotes:

[1] *Climate of Washington*. Western Regional Climate Center. Sept. 2009 www.wrcc.dri.edu/narratives/WASHINGTON.htm
[2] *In Town, Out-of-Doors facts*. Seattle's Convention and Visitors Bureau. Sept. 2009 http://www.visitseattle.org/
[3] *Seattle Visitor Information – Weather*. 26 Jul. 2003. GoNorthwest Travel Guide. Sept. 2009 www.gonorthwest.com/Washington/seattle/weather.htm
[4] *Enumclaw – Climate & Weather*. Key to the City. Sept. 2009 http://www.usacitiesonline.com/wacountyenumclaw.htm
[5] *Enumclaw Area Chamber of Commerce.* Sept. 2009 http://www.enumclawchamber.com/chamber.htm
[6] *Snoqualmie Falls, Washington – Period of Record Monthly Climate Summary*. Western Regional Climate Center. Sept. 2009 www.wrcc.dri.edu/cgi-bin/cliMAIN.pl?wasnoq
[7] *Weather*. Snoqualmie Valley Chamber of Commerce. Sept. 2009 www.snovalley.org/vn_weather.html
[8] Western Regional Climate Center - *Seattle Urban Site, Washington – Period of Record Monthly Climate Summary*. Western Regional Climate Center. 31 Dec. 2008 http://www.wrcc.dri.edu/cgi-bin/cliMAIN.pl?wa7473
[9] *Seattle Climate Data Monthly Summary*. Beautiful Seattle. Sept . 2009 www.beautifulseattle.com/clisumm.htm
[10] *"400,000 Lose Power – But Storm Not as Bad as Had Been Feared*." Seattle Times 13 Dec. 1995: A.1.
[11] *"Storms Leave 4 Dead, 1M Without Power."* KIROtv.com 15 Dec, 2006 http://www.kirotv.com/weather/10544585/detail.html?rss=sea&psp=eastsidenews
[12] *"Storm death toll reaches 8 as 200,000 still without power."* KOMONews.com 16 Dec, 2006 http://www.komonews.com/news/4935976.html
[13] *"Barn-Buster Windstorm Really Was a Tornado."* Seattle Times 8 Sept, 2009: A.1.

Several substantive additions made for 2009

Introduction

Avalanche hazards in the Northwest are associated with winter storms in the Cascade and Olympic Mountain ranges. Avalanches occur when a snow pack loses its grip on a slope and slides downhill. Typically, slopes of between 20 to 30 degrees and snow packs of 34 inches or more may produce avalanches.[1]

There are two kinds of avalanches, loose and slab. Loose avalanches occur when light-grained snow exceeds its angle of repose, collapses a snow drift or bank and fans out as it slides downhill. A slab avalanche occurs when heavy or melting snow resting on top of looser snow breaks away from the slope and moves in a mass. The latter often occurs when rains soak the top layer of snow on moderately sloped terrain.

The factors that cause avalanches are numerous and complex. Scott Kruse lists twelve common factors: old snow depth, old snow surface, new snow depth, new snow type, snow density, snow fall intensity, precipitation intensity, settlement, wind direction and wind speed, temperature, subsurface snow crystal structure, and tidal effect.[2] Research done at Snoqualmie Pass indicates that most natural avalanches occur within one hour after the onset of rain over a weakened snow pack.[3]

High Probability Low Impact	**High Probability Moderate Impact**	**High Probability High Impact**
Moderate Probability Low Impact	**Moderate Probability Moderate Impact**	**Moderate Probability High Impact**
Low Probability Low Impact	**Low Probability Moderate Impact**	**Low Probability High Impact**

Avalanche Probability and Avalanche Impact

A variety of mitigation efforts have significantly reduced the potential impact on humans and property. See Past Mitigation Efforts of this hazard.

Hazard Identification

Avalanche danger is highest during severe winter weather. It is also true that most natural avalanches occur in back country little used by humans during such weather conditions. This tends to minimize exposure to avalanche impacts. Most at risk are travelers and winter recreation enthusiasts using Steven's Pass in northern King County, Snoqualmie Pass in central King County, and Crystal Mountain Ski Area near Chinook Pass in southern King

County. Recreational areas that support snowshoeing, alpine and cross-country skiing, snowmobile areas, and winter hikers and campers are most at risk from avalanche events. Typically, injuries to recreational hikers, skiers, snow boarders, and climbers occur outside managed areas.

Several stretches of Interstate 90 and Highway 2 in King County are vulnerable to avalanches between November and May each year, depending on snow packs and weather conditions.

Both Snoqualmie and Steven's Pass are significant commercial routes. Cargos are carried between the Ports of Tacoma and Seattle, and eastern Washington. When Stevens and Snoqualmie Passes are closed, air travel is the only practical way to travel between Spokane and Seattle.

History of Events

The most significant avalanche event in Washington State occurred in 1910 near Steven's Pass. A train carrying passengers was hit by an avalanche killing 96 people.[4] In early 2008, heavy rain associated with snowfall has accounted for the closure of Interstate 90 at Snoqualmie Pass, resulting in delays of over 24 hours.[9] The table below represents recent and significant avalanche events in King County.

Table 5-3: Avalanche History

Year	Location	Impact
1910	Steven's Pass[5]	96 killed
1962	Steven's Pass	2 buried
1966	Snoqualmie Pass	1 buried
1971	Snoqualmie Pass	1 killed
1993	Snoqualmie Pass	5 injured
1994	Steven's Pass	11 injured
1996	Snoqualmie Pass	2 buried
1996	Alpental (Snoqualmie Pass)	2 dead
1996-97	Snoqualmie Pass, I-90	Repeated closure of Pass, stranding travelers several days
2001	Steven's Pass	2 killed
2002	Snoqualmie	I-90 road closures lasting multiple days
2002	Steven's Pass	3 injured
2003	Alpental	1 killed
2003	Snoqualmie Pass	1killed, 1 injured
2005	Alpental	1 killed
2007	Snoqualmie	2 killed, 1 injured

Source: Washington State Emergency Management Division, Hazard Identification and Vulnerability Analysis, Sept. 2009.
http://www.nwac.us/accidents.htm

Periodically each winter season, Snoqualmie and Stevens Passes both close for several hours for avalanche control measures. During the 2002-03 winter season, there were 30 deaths from avalanches in Washington State. Un-inhabited alpine areas in the Cascades north and south of Interstate-90 experience hundreds of avalanches annually.[6]

Hazard Impacts

Impacts on King County from avalanche closures of Snoqualmie Pass include economic impacts to the Port of Seattle, ski areas, and the cities of Snoqualmie, North Bend, Skykomish, and Issaquah. Motorists and truckers are often re-routed through Interstate 84 in Portland.[7] Stranded motorists occupied shelters and hotel space in Snoqualmie, North Bend, Issaquah and Bellevue. During the winter of 1996-97, I-90 was closed for 276 hours. The later closures cost the State of Washington an estimated 144 million dollars (2002).[8]

Avalanches pose a hazard for ski resorts in the eastern edge of King County within the Cascade Range. Warm temperatures and severe snowstorms account for trapped or buried skiers in particular the Snoqualmie area where activity is the highest. In the winter of 2007 there were two recorded incidences of skiers trapped or killed by avalanches, following similar trends from the previous winters of 2003-04 and 2005. [10]

In late January of 2008, severe winter storms and warm temperatures caused the closure of I-90 due to avalanches. For nearly 4 days WSDOT crews worked non-stop to clear a series of avalanches on Snoqualmie Pass following a declared State of Emergency by Governor Gregoire. [11]

Past Mitigation Efforts

Avalanche research began in the mid-1940s. By 1952 Stevens Pass was one of three research stations in the United States. The use of artillery for avalanche control was one of the developments of that research. Washington State Department of Transportation (WSDOT) is responsible for avalanche control. The WS DOT snow and ice removal budget was $20,000,000 in 1996, the most recent available data provided.[8] This money has been used to control avalanche hazards along major roadways. The roadway covering along I-90 near Snoqualmie and the 7.8 mile tunnel at Stevens Pass was constructed to protect rail lines from avalanches in 1929.[3] The National Weather Service Avalanche Center provides reports on avalanche conditions and issues advisories.

Avalanche Endnotes

[1] Washington State Department of Transportation, Prediction of Snow and Avalanches in Maritime Climates: Final Report, WA-RD 203.1, December 1989, p.3.
[2] Avalanche Evaluation Check List by Scott M. Kruse in the Avalanche Review vol. 8, No 4, February 1990
[3] Washington State Department of Transportation, Prediction of Snow and Avalanches in Maritime Climates: Final Report, WA-RD 203.1, December 1989, p.1.
[4] Description of the Wellington (Stevens Pass) avalanche, http://www.cisackson.com/Skykomish/
[5] "In mountains, experience sometimes isn't enough" by Joe Nabbefeld, Seattle Times, December 27, 1996, p. B1
[6] *"Cold Snap May Help Situation in Passes"* by Richard Seven, Seattle Times, February 11, 1990, p. A1
[7] Washington State Emergency Management Division, Hazard Identification and Vulnerability Analysis, draft, May 2003
[8] Washington State Emergency Management Division, Hazard Identification and Vulnerability Analysis, June 1996, P. A2
[9] "*I-90 at Snoqualmie Pass closed until Friday"* King/King5.com, 31 Jan, 2008
http://www.king5.com/localnews/stories/NW_013108WXB_avalanche_snoqualmie_LJ.7728aace.html
[10] Recent Accident Summaries, Avalanche Accident Data
http://www.nwac.us/accidents.htm
[11] -Storm-Related Closures of I-5 and I-90: Freight Transportation, Economic Impact Assessment Report, Winter 2007-08, Sept. 2008
http://www.wsdot.wa.gov/NR/rdonlyres/8FCFF2CF-4ACC-461A-96A6-AA310CCF6050/0/WSDOT_I5_90ClosuresFinalReport.pdf

Flooding

Substantive additions made for 2009

Introduction

Typically, snow accumulation melting runoff waterflow is towards Eastern Washington rivers and tributaries, not western Washington. Flooding in King County occurs primarily when large wet and warm weather systems, usually known as a "Pineapple Express", occur in the Cascade Mountains and after large snow packs have accumulated. The combination of warmer temperatures, quickly melting snow runoff and added precipitation can fill rivers within hours but usually build over one to three days. For this reason most flooding occurs in the winter months.

Rainfall in geographic King County varies widely from city to city and area to area. The City of Seattle has an average of 37 inches annually,[1,2] while Enumclaw has an annual average of 55 inches[3,4] and Snoqualmie/North Bend has 62 inches[5,6] of precipitation. The majority of this precipitation occurs as rain in the lowlands between October and early May with substantial snow packs in the Cascades during the same time frames.

High Probability Low Impact	**High Probability Moderate Impact**	**High Probability High Impact**
Moderate Probability Low Impact	**Moderate Probability Moderate Impact**	**Moderate Probability High Impact**
Low Probability Low Impact	**Low Probability Moderate Impact**	**Low Probability High Impact**

Flooding Probability and Flooding Impacts

Note: The 2009 hazard vulnerability, or impact, for the next 3 -5 years has been changed to high/high, from high/moderate in 2004. This is because of the Green River Valley risk of potential flooding in the next three to five year period due to the Howard Hanson Dam situational awareness.

Hazard Identification

These first three paragraphs were added for the 2009 Plan update by the King County Department of Natural Resources and Parks, Water and Land Resources Division.

Major flood events along King County's rivers result in two primary types of flood hazards: inundation and channel migration. Inundation is defined as floodwater and debris flowing through an area that is not normally under water.

Such events can cause minor to severe damage, depending on the velocity and depth of flows, the duration of the flood event, the quantity of logs and other debris carried by flows, and the amount and type of development and personal property in the floodwater's path.

Channel migration results from erosion, which is the wearing away of a riverbank by flowing water. Ongoing erosion of one riverbank coupled with sediment deposition along the opposite bank results in the lateral movement, or migration, of a channel across its floodplain. A channel can also move by abrupt change in location, called avulsion, which can shift the channel location a large distance in as short a time as one flood event.

King County identifies areas that are at risk from flooding and channel migration using a variety of mapping, analytic, and property tracking approaches. Flooding due to channel migration has been mapped in four areas of the major King County rivers and tributaries, covering a total of 49 river miles. Major flood events in King County have resulted in significant property damage. King County has been declared a federal disaster eleven times since 1990 with damages well over $350 million. The most severe recent flood event was the January 2009 flood.

In 2004, King County had identified several low-lying areas that are susceptible to flooding on an annual basis to varying degrees. Neal Road, Southeast Reinig Road and Northeast Walker Road may flood at Phase II on the Snoqualmie River while at Flood Phase III water covers the lower Mill Creek basin roadways. Cities that have experienced significant river flood impacts include Auburn, Bothell, Carnation, Duvall, Issaquah, Kent, North Bend, Renton, Snoqualmie, and Tukwila.

Flood Level Phases and Precipitation

Flooding incidents in King County are described in Flood Phases for individual river systems.[8]

Flood Phase I:	Rivers running bank full
Flood Phase II:	Some minor flooding and water over roadways
Flood Phase III:	Some homes inaccessible, roadways overtopped, water velocities may be dangerous with some debris
Flood Phase IV:	Homes in low-lying areas flooding with significant damage and threat to life and safety

Table 5-4 shows there is am annual buildup of snow pack in December through March with a rapid melt-off of that snow pack while spring rains continue. Heavy

rains in November and December, when accompanied by fluctuating temperatures, can trigger events similar to spring melts. Thanksgiving weekend has often been noted as the beginning of flood season in King County.

Table 5-4: Precipitation in Inches

Month	Average Snowfall[7]	Average Snow Pack[7]	Average Rainfall[5,6]
January	109.04	70	8.50
February	73.78	91	6.14
March	71.42	96	6.09
April	25.87	76	4.44
May	3.47	32	3.45
June	Nil	2	3.01
July	Nil	0	1.43
August	Nil	0	1.54
September	Nil	0	3.01
October	5.30	0	5.56
November	51.08	10	8.84
December	96.93	37	9.09

Note: Measurements for snow was taken at Snoqualmie Pass and rain taken at the City of Snoqualmie Falls.

Major Rivers that are susceptible to flooding inhabited communities and roadways are (in cubic feet per second – cfs).[8]

Table 5-5: Flood Phase Levels Used By King County Flood Warning Center

River System	Phase I	Phase II	Phase III	Phase IV
Snoqualmie River – Sum of the Forks	6,000 cfs	12,000 cfs	20,000 cfs	38,000 cfs
Cedar River	1,000 cfs	2,800 cfs	3,500 cfs	4,200 cfs
Tolt River	1,500 cfs	2,500 cfs	4,500 cfs	7,000 cfs
Green River	5,000 cfs	7,000 cfs	9,000 cfs	12,000 cfs
White River	5,000 cfs	8,000 cfs	10,000 cfs	12,000 cfs
Issaquah Creek	6.5 ft	7.5 ft	8.5 ft	9.0 ft

For the 2009 Plan update, the King County Department of Natural Resources and Parks, Water and Land Resources Division has provided a very detailed analysis of the 6 major King County river basins. The analysis is located Section 6 of the Plan, after Table 6.1, titled King County Major River Basins. This documentation includes land use, structures, estimating potential losses, development trends, and repetitive loss properties.

Table 5-5A: Major King County River Basins, detailed in Section 6**, a new table in 2009**
South Fork Skykomish River
Snoqualmie River
Sammamish River
Cedar River
Green River
White River

Flood Forecasting (new in 2009)

For the 2009 Plan update, the King County Department of Natural Resources and Parks, Water and Land Resources Division (DNRP) has provided this following information about flood forecasting: 11.5

King County's current ability to provide flood flow forecasts is limited. Flow measurements taken in the upstream portions of a watershed are used by flow forecasters to generate short-term predictions for downstream areas. By comparing the relationships between conditions at the upstream and downstream locations during previous flood events, the travel time of a flood peak can be roughly estimated. However, because both the weather and the river systems are dynamic, each flood is different. Weather variations include the timing and intensity of precipitation, the temperature and snow level, the wind speed and direction, and the storm cell's location, speed, and direction of travel. River system variations include local factors such as log jams, bank erosion, landslide and gravel bar formation, as well as upstream flow control factors, such as dam operations. Antecedent conditions, which include previous rain and snow pack conditions, also affect the amount and timing of storm runoff. Because these dynamic variations influence the relationships between flood conditions at different locations, any predictive use of those relationships will always include a degree of uncertainty.

The National Weather Service's River Forecasting Center in Portland, Oregon issues short-term predictions of flows on rivers in Washington, Oregon, Idaho, and western Montana. These short-term flow predictions are based on two computer models: the National Weather Service River Forecast System and the Streamflow Simulation and Reservoir Regulation. Each of these models simulates soil, snow, stream channel and reservoir conditions in order to estimate resulting river flow conditions. Daily forecasts are made using observations of temperature and precipitation. Forecast of meteorological parameters are included in the river forecast model. These National Weather Service predictions are issued for several forecast points in King County, including Middle Fork Snoqualmie River near Tanner, North Fork Snoqualmie near Snoqualmie Falls, South Fork Snoqualmie River near Garcia, Snoqualmie River at Snoqualmie Falls and at Carnation, Tolt

River near Carnation, Cedar River at Landsburg and Renton, Green River at Auburn, White River near Buckley and Issaquah Creek near Issaquah.

The Seattle office of the National Weather Service provides additional forecast detail when flooding is likely, and throughout flood events, with flood watch and flood warning statements. While the National Weather Service forecast information is valuable and widely used, an additional independent model would be beneficial. A model designed specifically for King County and adjacent watersheds would improve the ability of Flood Warning Center staff to interpret incoming gage and National Weather Service data, and to give meaningful forecasts to others. 11.5

History of Events

This is a new Table 5-5B in 2009, this section has been updated from the 2004 Plan, history of events list, to provide more complete information.

Table 5-5B: Gage Information Data from Past Floods [14]				
	Date	**Feet**	**Flows**	**100-Year Flow or Regulated Flows**
Skykomish River Near Gold Bar Gage (1)				
	11/06/2006	24.51 ft	129,999 cfs	119,300 cfs
	11/24/1990	22.49 ft	102,000 cfs	119,300 cfs
	12/26/1980	21.34 ft	90,100 cfs	119,300 cfs
North Fork Snoqualmie River Near Snoqualmie Falls Gage (2)				
	1/07/2009	13.42 ft	17,100 cfs	18,000 cfs
	2/26/1932	17.50 ft	15,800 cfs	18,000 cfs
	11/29/1995	12.82 ft	14,500 cfs	18,000 cfs
Middle Fork Snoqualmie River Near Tanner Gage (3)				
	11/06/2006	15.32 ft	31,700 cfs	37,100 cfs
	1/07/2009	15.22 ft	31,200 cfs	37,100 cfs
	12/02/1977	14.93 ft	30,200 cfs	37,100 cfs
South Fork Snoqualmie River Above Alice Creek Near Garcia Gage (4)				
	11/06/2006	18.68 ft	8,910 cfs	11,000 cfs
	11/23/1986	8.33	8,450 cfs	11,000 cfs
	11/24/1990	18.26 ft	8,000 cfs	11,000 cfs
Snoqualmie River Near Snoqualmie Gage (5)				
	11/24/1990	21.55 ft	78,800 cfs	79,100 cfs
	11/23/1959	19.78 ft	61,000 cfs	79,100 cfs
	1/07/2009	20.97 ft	60,700 cfs	79,100 cfs
Snoqualmie River Near Carnation Gage (6)				
	1/08/1990	62.65 ft	83,400 cfs	91,800 cfs
	11/07/2006	61.28 ft	71,800 cfs	91,800 cfs
	11/24/1990	60.70 ft	65,200 cfs	91,800 cfs
Snoqualmie River at Duvall Gage (7)				
	1/08/2009	45.18 ft	See note 7	See note 7
	11/30/1995	44.36 ft	See note 7	See note 7
	11/08/2006	42.89 ft	See note 7	See note 7

Raging River Near Fall City Gage (8)				
	11/24/1990	6.56 ft	6,220 cfs	6,970 cfs
	11/23/1986	6.27 ft	5,330 cfs	6,970 cfs
	1/9/1990	6.02 ft	4,640 cfs	6,970 cfs
Tolt River Near Carnation Gage (9)				
	1/08/2009	12.58 ft	17,900 cfs	18,800 cfs
Before the dam	12/15/1959	13.04 ft	17,400 cfs	18,800 cfs
Before the dam	2/09/1951	12.92 ft	16,800 cfs	18,800 cfs
Cedar River Near Landsburg Gage (10)				
	11/19/1911	Unknown	14,200 cfs	10,300 cfs
	11/15/2006	Unknown	12,400 cfs	10,300 cfs
	11/24/1990	10.38 ft	10,800 cfs	10,300 cfs
Cedar River at Renton Gage (11)				
	11/24/1990	17.13 ft	10,600 cfs	12,000 cfs
	1/08/2009	16.27 ft	9,400 cfs	12,000 cfs
	12/04/1975	14.14 ft	8,800 cfs	12,000 cfs
Green River Below Howard Hanson Dam Gage (12)				
Before the dam	2/21/1961	14.40 ft	12,200 cfs	
	1/05/1984	14.22 ft	11,100 cfs	12,000 cfs regulated
	2/17/1981	13.89 ft	10,800 cfs	12,000 cfs regulated
Green River Near Auburn Gage (13)				
Before the dam	11/23/1959	69.75	28,100 cfs	
Before the dam	12/11/1946	68.16 ft	22,000 cfs	
Before the dam	12/12/1955	67.73 ft	20,300 cfs	
White river Near Buckley Gage (14)				
Before the dam	12/02/1933	Unavailable	28,000 cfs	
Before the dam	2/26/1932	Unavailable	17,000 cfs	
Before the dam	11/30/1995	Unavailable	16,500 cfs	
	11/24/1986	Unavailable	15,200 cfs	12,000 cfs regulated
White River Near Auburn (15)				
	2/10/1996	83.15 ft	15,000 cfs	15,500 cfs
	11/09/2006	85.79 ft	14,700 cfs	15,500 cfs
	1/09/1990	82.07 ft	14,500 cfs	15,500 cfs

(1) USGS Station 12134500 located at RM 43.0, roughly 6.6 miles below South Fork & North Fork confluence
(2) USGS Station 12142000 located at RM 9.2 roughly 0.6 miles above Calligan Creek
(3) USGS Station 12141300 located at RM 55.6 roughly 0.7 miles below Granite Creek
(4) USGS Station 12143400 located at RM 17.3 roughly 0.4 miles above Alice Creek
(5) USGS Station 12144500 located at RM 40.0 near the base of Snoqualmie Falls
(6) USGS Station 12149000 located at RM 23.0 beside the Carnation Farms Road Bridge
(7) USGS Station 12150400 located South of Woodinville-Duvall Bridge in Duvall. Because of hydraulic conditions, this gage records only flood states without flow estimates.
(8) USGS Station 12145500 located at RM 2.75 near the old concrete arch bridge (68th Street)
(9) USGS Station 12148500 located at RM 8.7 roughly 0.4 miles above Stossel Creek
(10) USGS Station 12117500 located at RM 23.4 roughly 1.8 miles above the water supply intake
(11) USGS Station 12119000 located at RM 1.6 near the Mill Avenue Bridge
(12) USGS Station 12105900 located at RM 63.8 roughly 0.7 miles below the dam
(13) USGS Station 12113000 located at RM 32.0 near the base of Lea Hill
(14) USGS Station 12098500 located at RM 27.9 roughly 1.7 miles downstream of Mud Mountain Dam
(15) USGS Station 12100496 located at RM 6.30 near A Street Bridge

Not all flooding incidents are eligible to receive federal assistance for public agencies. For this reason alone, mitigation efforts to minimize the impacts of flooding in King County can save a considerable amount of public monies needed to repair damages from modest-sized events. The following list of presidential disaster declarations were associated with listed King County flooding events listed above.

Often, Small Business Administration (SBA) loans are available to individuals and businesses that qualify without a presidential declaration of disaster.

Table 5-6: FEMA Flooding Disasters in King County Identified in 2004 Plan		
No.	Dates	KC Public Damages (FEMA Approved)
185	December 1964	Figures not available
328	February 1972	Figures not available
492	December 1975	Figures not available
545	December 1977	Figures not available
612	December 1979	Figures not available
757	January 1986	Figures not available
784	November 1986	Figures not available

The following were provided in 2009 from the King County Flood Control District for the 2009 Plan Update. 11.5

Table 5.7 2009 Update to FEMA Flooding Disasters in King County

Date of Flood	Declaration #	Type of Damage	Estimated Damages
January 1990	#852	Overbank flooding causing damage to both public and private property. Channel avulsion.	$17.8 million
November 1990	#883	Overbank flooding causing damage to both public and private property. Stream bank erosion.	$57 million
December 1990	#896	Overbank flooding causing damage to both public and private property. Levee damage.	$5.1 million
November 1995	#1079	Overbank flooding causing damage to both public and private property. Levee damage.	$45.9 million
February 1996	#1100	Overbank flooding causing damage to both public and private property. Stream bank erosion. Levee damage.	$113 million
December 1996	#1159	Overbank flooding causing damage to both public and private property. Channel avulsion.	$83 million

Date of Flood	Declaration #	Type of Damage	Estimated Damages
March 1997	#1172	Overbank flooding causing damage to both public and private property. Channel avulsion.	$6.5 million
November 2003	#1499	Overbank flooding causing damage to both public and private property.	$30 million
December 2006	#1671	Overbank flooding causing damage to both public and private property. Channel avulsion	Information not available
December 2007	#1734	Overbank flooding causing damage to both public and private property. Channel avulsion. Levee damage.	Information not available
January 2009	#1817	Overbank flooding causing damage to both public and private property. Channel avulsion. Levee damage.	Information not available

Hazard Impacts

Flooding impacts to the community include injuries to citizens and public safety officials, damage to property, lost revenue and economic damages, an increased demand on public safety and infrastructure related services. The King County Emergency Coordination Center (ECC) activates for flooding events of Phase III level or greater to coordinate resources, information, and response activities.

Response activities include unanticipated overtime for ECC activations and first responders, evacuations, sheltering of displaced people, rerouting traffic destined for impassible roads, bridge and road damage repairs, and rescue or medical missions related to motorists and isolated families. The Cities of Carnation, Duvall, and Pacific have been isolated as an entire community. Private property damages to homes and vehicles as well as land erosion, river channel changes, agricultural damages and livestock losses result in significant rural economic impacts to local residents and businesses.

The economic impacts as a result of flooding events are a significant hazard to regional commerce. The areas prone to flooding, the lower-lying banks and valleys near rivers, are densely developed with industrial and commercial activity. Though only 2% (32,000) of King County's residents are directly impacted, the employment of area citizens is greatly affected. Since the floodplain vicinities employ nearly 6% (65,000) of King County, the economy of the area at large is impacted far beyond the zones of flood risk. Of the industries specifically at higher risk, 30% of King County's manufacturing employment and 30% of its aerospace industry are located in floodplains. Nearly 7% of King County's total annual wages and salary income is created from businesses within flood zones. The consequences of a single day of economic shut-down within the floodplains would result in $46 million loss of county wide revenue. An estimated $3 million reduction of economic output would result from the areas of King County outside the flooded areas. [10.5]

Past / Present Mitigation Efforts

National Flood Insurance Program (NFIP) (*new for 2009*)

King County is nationally known for its work on flooding mitigation. In 1978 unincorporated King County entered the National Flood Insurance Program (NFIP).[9] The most recent review of King County's participation in the NFIP was conducted on January 15, 2009. The review, called a Community Assistance Visit, identified amendments needed to King County's flood regulations and through a field investigation found approximately 20 properties that had outstanding code violations for construction within the floodplain. The King County Council has approved an ordinance making the changes in the flood regulations and King County has made significant progress in resolving the code violations as of the date of this Plan update.

The Community Rating System (CRS), administered by the Insurance Services Office, enables residents in participating communities to purchase discounted flood insurance. The amount of discount each community receives is contingent upon its Community Rating System (CRS) rating corresponding to the extent of its floodplain management efforts.[10] For its extensive services in this respect – the implementation of programs such as buyouts for properties experiencing repeated flooding, maintenance of levees along pertinent rivers, and annual public meetings with affected communities, the County has earned a Class 2 rating, making it the highest rated community of any county in the nation. The result of this has been a 40 percent annual savings to flood insurance policy holders in unincorporated King County.[11]

King County Flood Warning Center *11.5* (*new for 2009*)

The purpose of King County's Flood Warning System is to warn residents and agencies of impending floodwaters on major rivers so they can take action and prepare themselves before serious flooding occurs. The Flood Warning Center is operated and staffed by King County through an interlocal agreement between King County and the King County Flood Control District for the County to provide the services to the District. The County monitors conditions in its six major river systems and their major tributaries 24 hours a day. When floods are imminent, King County activates its Flood Warning Center. King County personnel staff the operation, issuing warnings directly to police, fire departments, schools, cities, first response agencies, and citizen phone trees. Personnel at the Center are available to answer questions and help interpret gage readings during a flood event. There is also an automated voice message system that provides real time river flow information and other flood information. King County has developed and started testing a system that automatically sends out e-mail and pager alerts when real-time gage data exceeds flood

phase thresholds. This service is expected to be available to the public in time for the 2009-20010 flood season.

The County works closely with the National Weather Service to obtain forecast information used to make flood predictions. Close coordination occurs with the Office of Emergency Management, Roads Division, and other agencies in order to obtain up-to-date information about major flood problems, road closures, evacuations, and other emergency services. Coordination also occurs with the US Army Corps of Engineers and Seattle Water Department regarding dam operations.

Operation of the Flood Warning Center is based on a four-phased warning system, issued independently for each river. The thresholds for each phase are based on river gages, which measure the flood flow and stage (depth) of the major rivers in various locations. At Phase III or greater, flood patrol crews are sent out in the field to monitor flood protection facilities and respond to flood emergencies and reported problems around the clock. Significant information about flood conditions in the field, such as road and flood protection facility damages or overtopping, are reported back to the Flood Warning Center, to be shared with the public and emergency responders. The Flood Warning Center maintains communication with the King County Emergency Coordination Center (KC ECC) to coordinate emergency response and recovery. 11.5

Green River Valley Potential Flooding (*new for 2009*)

The U.S. Army Corps of Engineers (USACE) has discovered damage to a portion of the Howard Hanson Dam right abutment in early 2009. This dam has controlled flooding in the Green River Valley since 1962. However the dam will only operate at 30% capacity this winter, 2009, and possibly for an additional 3-5 years. Therefore, there is a much greater risk of significant flooding during periods of heavy rain throughout the lower Green River Valley, affecting the cities of Auburn, Kent, Renton, Tukwila, and south Seattle and surrounding infrastructure. 13

The USACE is actively testing and investigating the source of the problems and trying to identify solutions. The USACE has significantly reduced the water storage levels at the Dam and is taking a number of steps to try and minimize the flood risk. However, the USACE does not anticipate a full solution to the problems with the Dam by this flood season. 13

The Army Corps of Engineers is constructing a grout curtain within the abutment of the dam to reduce seepage through a critical area of concern, as well as performing drainage improvement work to route water into the drainage tunnel. Work is expected to be done by Nov. 1, 2009.12

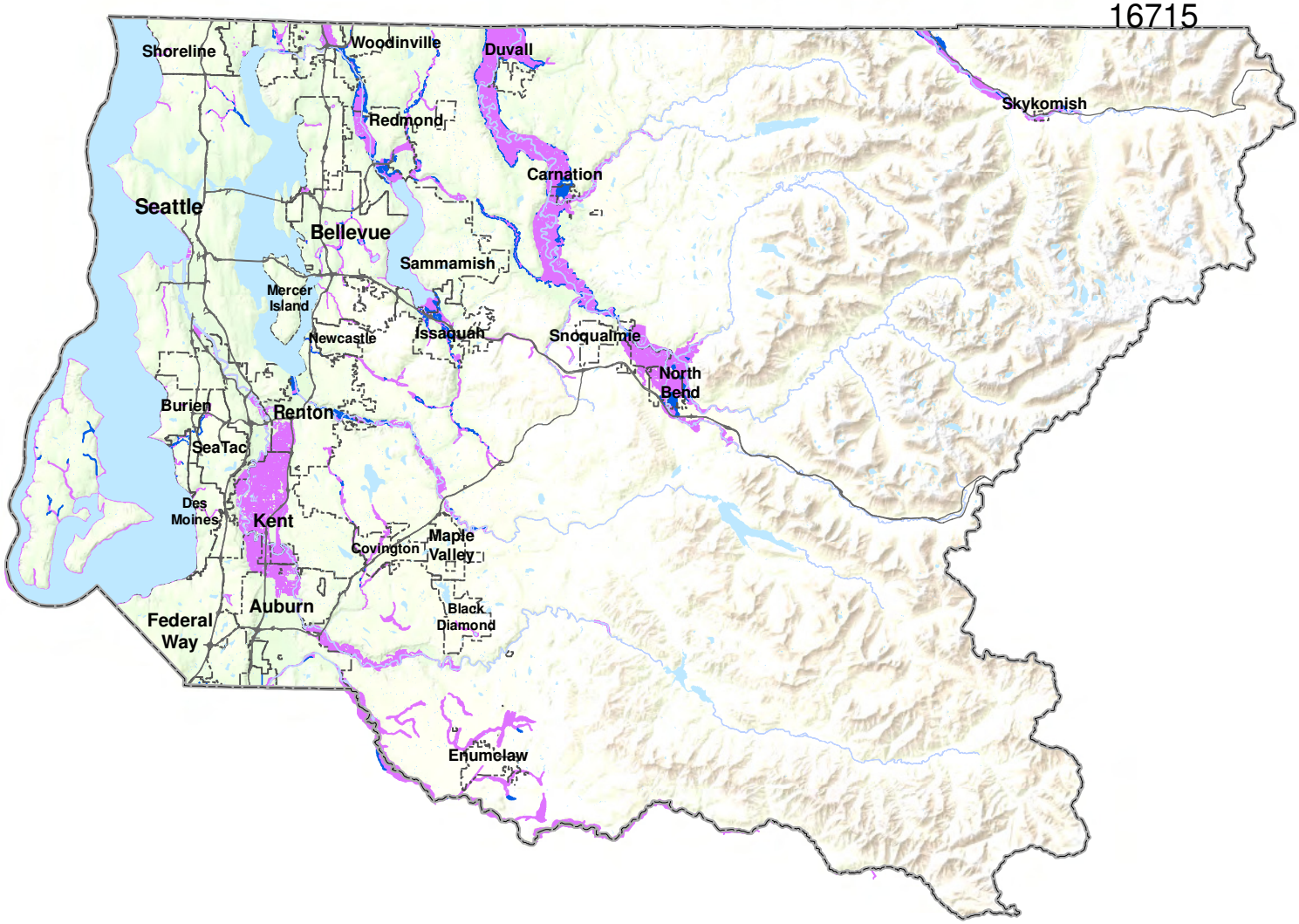
In September 2009, the U.S. Army Corps of Engineers (USACE) announced that it will purchase and pre-position flood fighting supplies and materials for the Green River Valley in preparation of the upcoming flood season.[12]

More information is detailed in the 2009 Dam / Dam Safety hazard identified in Section 5 about the Howard Hanson Dam and potential impacts to the Green River Valley for 2009, and for possibly 3-5 more years until the repairs or solution(s) can be in place.

Flooding Endnotes:

[1] GoNorthwest Travel Guide, www.gonorthwest.com
[2] Seattle's Convention and Visitors Bureau, www.seeseattle.org
[3] Key to the City, www.usacitiesonline.com/
[4] Enumclaw Area Chamber of Commerce, http://www.enumclawchamber.com/chamber.htm
[5] Western Region Climate Center, www.wrcc.dri.edu
[6] Sno valley Chamber of Commerce, http://www.snovalley.org/index.html
[7] Snoqualmie Pass Monthly and Seasonal Totals and Averages 2007-08, http://www.wsdot.wa.gov/NR/rdonlyres/7C5D5B02-0237-46DD-8AD2-3F3C0226485D/51434/111008HistoricalSnowfallthrough0708season.pdf
[8] King County Dept of Natural Resources and Parks, brochure - Flood Warning Information, http://www.kingcounty.gov/environment/waterandland/flooding/flood-control-zone-district.aspx
[9] FEMA Federal Insurance Administration, http://www.fema.gov/business/nfip/
[10] FEMA – Flood Insurance, http://www.fema.gov/library/viewRecord.do?id=3323
[10.5] *Economic Connections Between the King County Floodplains and the Greater County Economy,* King County Water and Land Resources Division, ECONorthwest, Oct 2007
[11] KC Department of Development and Environmental Services - News Release, http://www.kingcounty.gov/property/permits.aspx
[11.5] King Department of Natural Resources and Parks, Water and Land Resources Division, River and Floodplain Management, September 2009
[12] USACE (United States Army Corps of Engineers), Press Release, September 22, 2009
[13] Public Health Seattle & King County (PHSKC) September 3, 2009, Bulletin http://www.kingcounty.gov/healthservices/health/preparedness/greenriverbasin.aspx
[14] 2009-2010 Flood Warning Instruction Book, October 2009, King County Department Of Natural Resources and Parks, Water and Land Resources Division.

Attachment A
16715



Flood Hazard Areas

100 Year Flood Zone

500 Year Flood Zone

King County GIS
US Geological Survey
Washington State Department of Natural Resources, Division of Geology and Earth Resources

October 2009
Tetra Tech, Inc.

0 5 10 20 Kilometers

0 5 10 20 Miles

N
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S

King County

Substantive additions made for 2009

Introduction

Landslides are a common problem within King County. Landslide events in King County are most often associated with either unusually heavy seasonal rains or local earthquake activity. Urban areas of western King County have been developed for residential structures in many places. The vistas provided by the Olympic Mountains and Puget Sound are breathtaking backdrops to the Seattle skyline. Despite the possibility of landslide events, property values continue to rise disproportionately and development of available properties continues.

View homes and property values can reach and even exceed $500,000 in some landslide areas, making even the loss of only a few homes significantly costly.

High Probability Low Impact	**High Probability Moderate Impact**	**High Probability High Impact**
Moderate Probability Low Impact	**Moderate Probability Moderate Impact**	**Moderate Probability High Impact**
Low Probability Low Impact	**Low Probability Moderate Impact**	**Low Probability High Impact**

Landslide Probability and Landslide Impacts

Hazard Identification

The slopes of Magnolia, West Seattle, Burien, Des Moines, Vashon Island, Newcastle, Federal Way and many areas of Bellevue have long been developed for their magnificent views of Mount Rainier, the Cascade and Olympic Mountains, and Puget Sound. Three major factors that contribute to landslide activity and possible impacts to structures include soil type, slope angle, and precipitation levels.

Soil conditions vary widely in King County. In geological terms, King County's landscape is very young. As recently as 14,000 years ago, the region was covered by up to 3,000 feet of ice. The Vashon Glacier, which extended from Canada to south of Olympia carved valleys as it expanded and left soil deposits and rock as it retreated. Evidence of this activity is still observed in the "U" shaped valleys and stony soils common to Puget Sound. Seas rose 300 feet worldwide from the global melting following that ice age, creating Puget Sound as we know it today.[1]

The top layer of soil in King County is referred to as Vashon till, a stable mixture of rocks, dirt, clay, and sand that reaches depths of up to 30 feet. The next

layer, Esperance sand, is a permeable mixture of sand and gravel. This layer sits upon an impermeable layer of Lawton clay, made up of fine sediments and large boulders. Often, slides occur at this boundary interface when water runs laterally on top of this boundary.[2]

In some ways, landslide areas are similar to avalanche terrain. Characteristics of landslide hazard areas include:[3]

1. A slope greater than 15 percent
2. Landslide activity or movement in the last 10,000 years
3. Steam or wave action with erosion or bank undercutting
4. The presence or potential for snow avalanches
5. The presence of an alluvial fan that indicates vulnerability to the flow of debris or sediments
6. The presence of impermeable soils, such as silt or clay, which are mixed with granular soils such as sand and gravel

History of Events

Landslides have been a significant problem in the Puget lowland areas for many years, and several landslides occur every year during the rainy season. Storms have triggered significant numbers of landslides in 1972, 1986, 1990, 1996, 1997, early 2006, 2007, and 2009. Comparison of the locations of (more) recent landslides with those mapped by “Tubbs” reveals that many of the 1997 landslides are in the same general areas as the 1972 landslides.[9]

Very heavy rains in King County resulted in significant slides and associated damages in 1972.[6] Seventy percent of the slides occurred during the two following days.[7]

The most widespread landslide activity was secondary to the severe winter storm events that hit the Puget Sound region during December 1996 through March 1997. Unusually heavy snow and rain in King County resulted in slides that damaged or destroyed 8,000 homes. Over 100 slides were recorded in King County over a two-month period. Particularly hard hit areas were slopes on Magnolia Hill (Seattle), areas along Interstate-5, and Vashon Island.[2,4]

A January 15, 1997 slide at Woodward in southern Snohomish County derailed five cars of a freight train. Passenger and cargo rail traffic was interrupted for nine days. Cargo traffic resumed first. Amtrak remained concerned for passenger safety and did not travel on this section of track for several weeks.[5]

Two weather events in November and December of 1998 caused a number of small slides in King County. Landslides along Interstate-5 near SeaTac Airport briefly closed portions of that northbound roadway.[8]

Heavy rains are not the only cause of landslides. The Nisqually earthquake caused a secondary hazard in February 2001, a landslide/mudslide causing a portion of hillside near Jones Road to slide into the riverbed of the Cedar River. The flow of the river was partially blocked for many hours resulting in several homes along the river being damaged by the dammed waters.

Evidence of slide activity can still be seen along the eastern side of Interstate-5 from King County Airport all the way to the Interstate-90 interchange where portions of hillside collapsed carrying trees and debris downhill, but just short of impacting Interestate-5.

In 2009, Washington State Department of Natural Resources, Division of Geology and Earth Resources, identified recent landslide numbers as provided in the Table 5-7, below. A landslide map distribution for years 2007 and 2009 is included at the end of Section 5. See **Map 5.1 Landslide locations for Jan. 2009 and Dec. 2007 Storms**. 13.5

Table 5-7: Landslide History

Event Date(s) & FEMA Event	Area	KC Public Damages
1972 Severe Weather	King County	$1.8 million
1996-97 Severe Weather (#1100, #1159, #1172)	King County	$9.0 million
2001 Nisqually Earthquake[13] (#1361)	Maple Valley/Cedar River	$1.71 million
2006 Winter, heavy rains for a month in January/February	Mercer Island	34 slides or more documented by Maintenance Director; $ unknown
2007 December Storm 13.5	King County	5 recorded $ unknown
2009 January Storm Landslides 13.5	King County	51 recorded, preliminary data, $ unknown

Source: FEMA Disaster Declaration, USGS[13]
Source: WA Department of Natural Resources; for both of the 2007 and 2009 events, the precipitation was fairy low compared to other parts of western Washington,13.5. Map 5.1 was created showing the distribution of the landslide locations and is located in the back of Section 5.

Hazard Impacts

Slides have resulted in direct damages to structures, roadways, rail lines, bridges, severed lifelines, and the blockage of the Cedar River (see “History of Landslide Events”). Indirect impacts included the isolation of small communities

or areas on Mercer Island, Vashon Island and Magnolia Hill, cost of debris clearance, personal injuries, and economic loses from rail and roadway closures, and debris clean up. The main impacts are disruption and economic.

Past / Future Mitigation Efforts

Efforts to reduce landslide-related losses have been ongoing for at least 20 years. Relative-slope-stability maps at several scales were developed in the 1970s for many of the urbanized areas surrounding Puget Sound (Miller, 1973; Artim, 1976; Smith, 1976; and Laprade, 1989). Most cities and many counties in the area regulate development of steep hillsides (Laprade, 1989). Despite these efforts, losses continue to mount because (1) economic growth continues to exert pressure to develop in or near landslide-prone areas; (2) increased erosion and consequent downcutting caused by urban runoff has locally reduced slope stability (Booth, 1989); and (3) new or previously unidentified landslides damage structures that were built in unstable areas before regulations existed.[10]

King County Surface Water Management maintains a response program related to landslides. The Emergency and Rapid Response Program funds efforts to prevent and recover from such events.[11]

In addition to the efforts at zoning and land use regulations initiated by the government, local citizen groups sometimes work to set aside environmentally sensitive or unstable areas as urban buffers. Such an action is being undertaken by the Denny Creek Neighborhood Alliance toward the purchase of property in the Juanita area near northern Lake Washington.[12] The area is well timbered and is being considered as an environmental buffer to prevent landslides.

An extensive list of codes related to land use and building restrictions for King County has been developed over many decades. For a complete list of codes governing building in King County, go to http://www.kingcounty.gov/property/permits/info/PermitTypes.aspx

In 2009, Washington State Department of Natural Resources, Division of Geology and Earth Resources, is in the process of creating a statewide landslide forecasting system, similar to the urban model in Seattle created by USGS, which will eventually have warnings issued from NOAA/NWS. 13.5

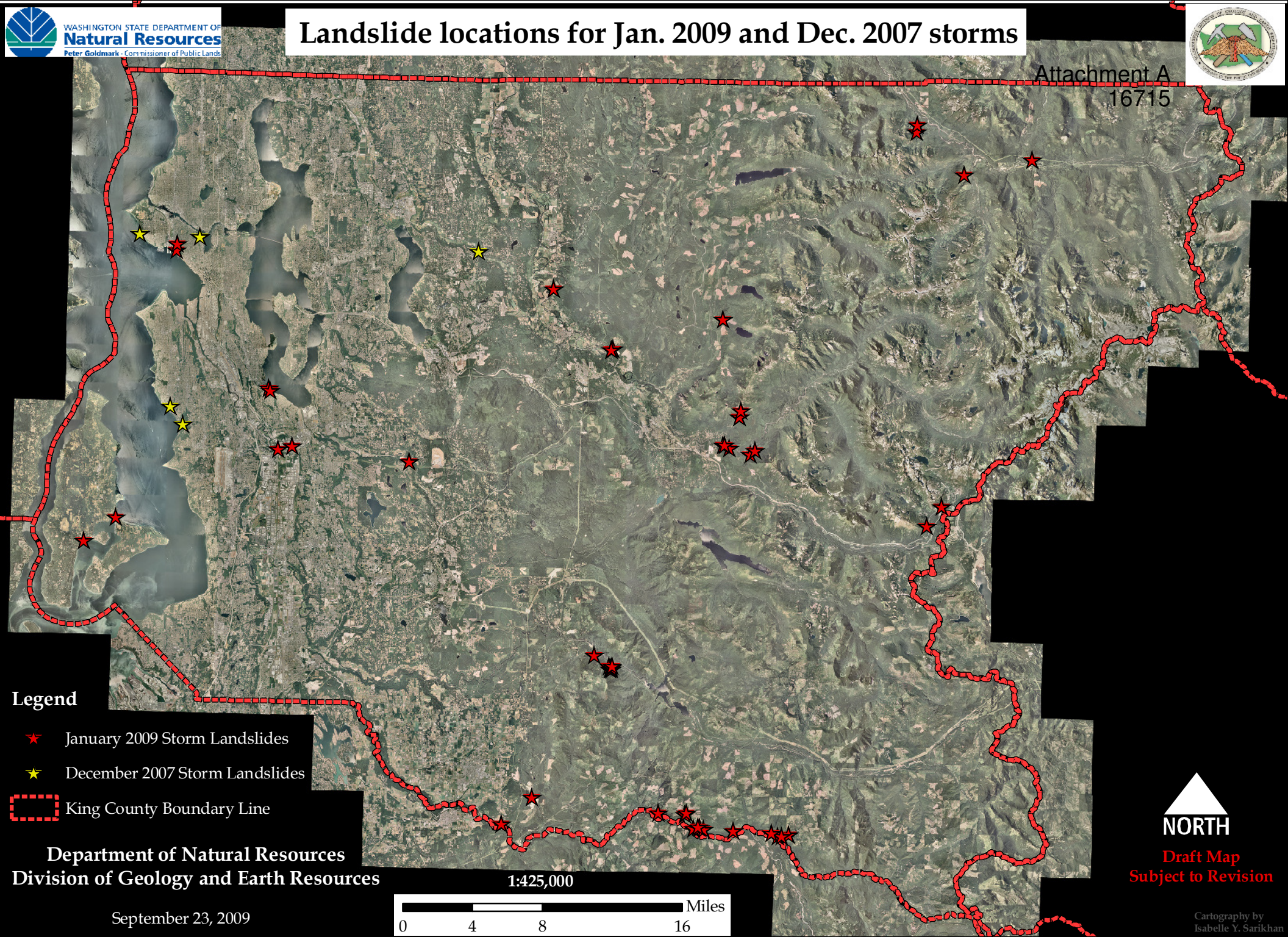
Land Slide Endnotes:

[1]Crozier, Michael J., Landslides: Causes, Consequences, and Environment, Croom Helm, Australia, 1986, p 195.
[2]Carter, Don and Scott Maier, "Slide-Wise, Danger Remains Real as Soggy Slopes are still unstable", Seattle Times, January 17, 1997, p A8.
[3]King County Planning and Community Development Division, "Landslide Hazard Areas", Sensitive Areas: Map Polio, Seattle Washington, 1990, p1.
[4] "It's Been a Winter of Mudslides on Area's Slopes', Seattle Times, January 20, 1997, p A2
[5]Washington State HIVA Draft May 2003
[6]McDoanld, Terrance J., "Landslides", Seattle: A Hazard Vulnerability Analysis, Master's Thesis, Cornell University, 1995, p 147
[7]Tubbs, Donald W., "Landslides in Seattle", Washington State Department of Natural Resources, Information Circular No 52, 1974, p4
[8]REex L. Baum and Aln F. Chleborad, Landslides triggered by Pacific Northwest Storms, November and December 1998, http://landslides.usgs.gov/recent/archives/pnw/table.php , January 14, 1999
[9]Rex L. Baum and Alan F. Chleborad, Geosettings and Landslides, Landslides triggered by the Winter 1997-1998 Storms in Puget Lowland, Washington, http://landslides.usgs.gov/docs/faq/significantls_508.pdf , Jul 13, 1998
[10]ibid
[11]Donald Althaueser, Emergency and Rapid Response, King County Department of Natural Resources and Parks, Surface Water Management Division, http://directory.metrokc.gov/ServiceDetail.asp?ServiceID=6659, July 2002
[12]Tony Dondero, Group Seeks to Buy Woodlands, Eastside Journal, July
[13] An Account of preliminary Landslide Damages and Losses Resulting from the February 28, 2001, Nisqually, Washington, Earthquake; Lynn M. Highland, USGS 2003; http://pubs.usgs.gov/of/2003/ofr-03-211/ofr-03-211.pdf
13.5 Isabelle Y. Sarikhan, Washington State Department of Natural Resources, Division of Geology and Earth Resources, Washington Geological Survey, Hazards Geologist & GIS Analyst, September 2009.

WASHINGTON STATE DEPARTMENT OF
Natural Resources
Peter Goldmark - Commissioner of Public Lands

Landslide locations for Jan. 2009 and Dec. 2007 storms

Attachment A
16715



Legend

- January 2009 Storm Landslides
- December 2007 Storm Landslides
- King County Boundary Line

Department of Natural Resources
Division of Geology and Earth Resources

September 23, 2009

1:425,000

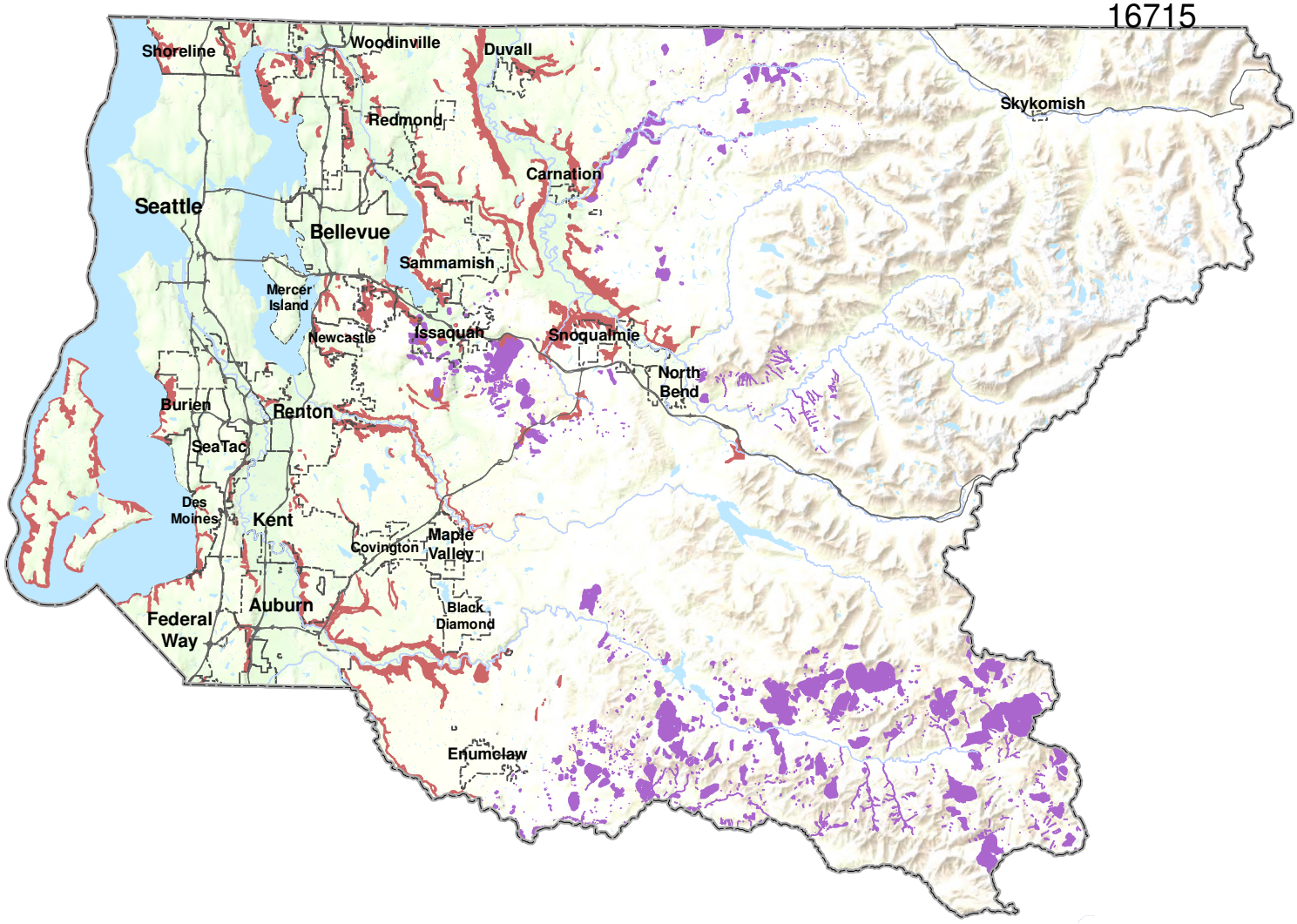
0 4 8 16 Miles

NORTH

Draft Map
Subject to Revision

Cartography by
Isabelle Y. Sarikhan

Attachment A
16715



Landslide Hazard Areas

King County Landslide Hazard Areas

King County Landslide Hazard Areas are areas subject to severe landslide risk identified in the Sensitive Areas Ordinance.

DNR Landslide Hazard Areas

The Department of Natural Resources, Geology and Earth Resources Division (DGER) Landslide dataset is a compilation of landslide data previously mapped by a variety of sources at all scales, and is assessed for reliability by the DGER.

King County GIS
US Geological Survey
Washington State Department of Natural Resources, Division of Geology and Earth Resources

October 2009
Tetra Tech, Inc.

0 5 10 20 Kilometers

0 5 10 20 Miles

N
W E
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King County

Several additions made for 2009

Introduction

Earthquakes can be the most destructive hazard King County can face if we have a moderate event on the Seattle Fault Zone. Earthquakes are described as the sudden release of energy occurring from the collision of crustal plates on the earth's surface or from the fracture of stressed rock formations in that crust. Though it can be said that there are many technical differences in the rocking, rolling, jarring and jolting felt during an earthquake, they can be devastatingly damaging and seriously unnerving.

King County is geographically located in an area known as the Pacific Ring of Fire. The same geological events that result in volcanic activity also generate notable earthquakes. Washington State is framed by the Pacific, North American, and Juan de Fuca plates, segments of the earth's crust. A significant number of active fault lines or cracks in that crust have been identified in the central Puget Sound area including Seattle and King County. On an annual basis, thousands of minor earthquake events occur in the greater Puget Sound Region.[1]

King County has a long history of documented earthquake activity. The most recent significant activity was the Nisqually Earthquake of February 28, 2001. This earthquake, 10 miles northeast of Olympia in Thurston County (over 40 miles from Seattle), resulted in statewide losses exceeding $1 billion and injured 700 people, many in King County.[2]

High Probability Low Impact	**High Probability Moderate Impact**	**High Probability High Impact**
Moderate Probability Low Impact	**Moderate Probability Moderate Impact**	**Moderate Probability High Impact**
Low Probability Low Impact	**Low Probability Moderate Impact**	**Low Probability High Impact**

Earthquake Probability and Earthquake Impacts

Hazard Identification

Most earthquakes go unnoticed by the residents of King County; significant numbers of 'dish rattlers' occur on a regular basis to remind people of their vulnerability. Over a thousand earthquakes occur in Washington State every year, most below magnitude 3.0. Some people and animals are more sensitive to these minor events than others. Usually, it requires a magnitude of 2.5-3.0 for a local shaker to be noticed. These happen on a fairly frequent basis (see

"History of Events"). Direct impacts from earthquakes may include damages to structures like buildings, pipelines, roadways, and bridges. Secondary impacts from earthquakes are common, and are known as secondary hazards. These can include tsunamis, seiches, and landslides. A slide in King County generated from the 2001 Nisqually Earthquake partially blocked the Cedar River – flooding several homes. Evidence of tsunami/seiche activity and major landslides has been identified from a 7.0 earthquake in Puget Sound around 900 A.D.

There are at least five active fault lines (crustal cracks) in the Puget Sound lowlands, any of which may impact King County. These are the Tacoma fault, Seattle fault, Darrington-Devil's Mountain fault, Utsalady Point fault, and southern Whidbey Island fault.[3] Many of these faults run east-west and extend for over 20 miles in length.

There are three technically distinct types of earthquakes: interplate or benioff zone earthquakes, subduction or interplate zone, and shallow crustal earthquakes. Each can generate powerful damaging motion in the greater Puget Sound area.[4]

Interplate or Benioff Zone Events[2]

These earthquakes occur at depths of 15 to 60 miles from the subducting Juan de Fuca plate. Examples of this type of damaging event include the Olympia earthquake in 1949, 1965 Seattle/Tacoma earthquake, 1999 Satsop earthquake and 2001 Nisqually earthquake. Depending on your location shaking could be felt for 15-50 seconds.

Subduction Zone Events[2]

Subduction zone events occur along the interface between tectonic plates. The energy generated from the collision of the Juan de Fuca, Pacific, and North American plates is considerable. These great magnitude events can reach 8.0 to 9.0 on the Richter scale, and the shaking could last for up to six minutes.

Shallow Crustal Earthquakes[2]

Shallow earthquake events occur within 20 miles of the earth's surface. These are fairly common events with typical magnitudes of up to 5.5, though there is some evidence that a number of shallow events have exceeded this figure.

History of Events

The State of Washington has experienced 20 damaging earthquake events in the last 125 years. Most of these have been in western Washington[5]. The 1965 Seattle-Tacoma earthquake and the 2001 recent Nisqually earthquake type of

events seem to reoccur about every 30 to 35 years, while a 1949 Olympia type event occurs about once every 110 years.

Subduction earthquakes do not recur based on anticipated time frames; events can be spaced anywhere from 100 to 1,100 years apart. The latest recorded subduction earthquake event in Washington State occurred in 1700.[6]

Table 5-8: Earthquake Events Felt or Impacting King County[7]

Date	Magnitude	Location
April 1945	5.7	12.5 km SSE of North Bend
February 1949	**7.1**	**12.3 km ENE of Olympia**
April 1965	**6.5**	**18.3 km N of Tacoma**
January 1995	5.0	17.5 km NNE Tacoma
July 1996	5.4	8.5 km ENE of Duvall
November 1996	2.9	Puget Sound
February 1997	3.0	SE of Seattle
April 1997	4.9	Puget Sound off Vashon Island
June 1997	2.7	Puget Sound
July 1997	3.1	Duvall
February 1998	2.9	NE of Seattle
March 1998	3.1	Pierce County
June 2000	3.4	Friday Harbor, San Juan Islands
February 2001	**6.8**	***Nisqually* – Olympia**
March 2001	3.4	Tacoma
May 2002	4.2	Friday Harbor, San Juan Islands
July 2002	3.1	North Bend
January 2009	4.5	Bremerton

Several small earthquakes over 4.0 were added to list in 2009 because of the proximity to Seattle.

Olympia Earthquake – April 1949[8]

The 7.1 magnitude earthquake was centered along the southern edge of Puget Sound. Eight people were killed and property damage in Olympia-Tacoma-Seattle amounted to about $25 Million in 1949 dollars. In Seattle, a sixty-inch water main ruptured, a radio tower collapsed, power lines and gas lines were broken in over 100 places. Three damaged schools needed to be demolished and one rebuilt.

Seattle-Tacoma Earthquake – April 1965[2]

At magnitude 6.5, the earthquake killed seven people and caused $12.5 Million in damage (1965 dollars). Severe shaking was felt in Seattle and as far east as Issaquah and beyond. Most damage was in the Pioneer Square area and waterfront. Older masonry buildings were most impacted. Damage patterns

experienced in 1949 were repeated. Eight schools were closed for inspections and repairs; two were severely damaged. Areas along the Duwamish River experienced severe settling. Three water mains failed in Seattle.

Nisqually Earthquake – February 2001[9,10]

The 6.8 magnitude earthquake was centered under Anderson Island in south Puget Sound. Soil geology resulted in the most extensive damage occurring along the Interstate-5 corridor, not around the epicenter. This pattern was the result of soft river bottom sediments (heavier damage) and improvements in building standards (lesser damage). Some damage was experienced in 300,000 households, many from settling foundations. Buildings built prior to 1950 located in the south downtown area and Pioneer Square in Seattle were the most impacted; structural damage to chimneys, walls, foundations and non-structural elements accounted for two-thirds of all damage reported.

Damages to airport runways and towers were significant and there were temporary closures of the SeaTac International and King County Airports as a result for several days for inspection and repairs. The Alaskan Way viaduct and Magnolia bridges were both closed until inspection and repairs were done. Of the 290 dams inspected by state engineers, only five had earthquake-related damage. A hillside collapse blocked the flow of the Cedar River; this resulted in flooding that impacted several homes along the river that were otherwise untouched by the earthquake shaking.

Hazard Impacts

The impacts to a community from earthquake events include injuries to citizens and public safety officials, damage to property, lost revenue and economic damages, increased demand on public safety and infrastructure related services. Added to the list for 2009 are critical infrastructure interruption, lifeline failures, building collapse, landslides, fires, tsunami / seiche (a large oscillation in an enclosed body of water). Utilizing a May 2005 HAZUS run, damage projections for a 6.7 magnitude earthquake centered in King County might damage more than 58,000 structures, displace 55,000 households, and result in up to 2,400 deaths and 800 injuries. These damages and impacts to the economy could reach $36 Billion.[11] Washington State ranks second only to California among states susceptible to earthquake damages.[12] Nationally, Seattle might incur the seventh largest potential dollar damages/losses.[2]

Populations and Economy at Risk

According to the 2000 US Census, King, Snohomish, Pierce, and Kitsap Counties are home to more than 60 percent of the state's population and much of its economic base.[13] Most vulnerable of these are non-English speaking individuals, people with disabilities, senior citizens, and people living in poverty,

and school-age children. Older brick homes and unreinforced masonry buildings without retrofitting are also at greater risk of incurring damage from an earthquake.

Table 5-9: Vulnerable Population Groups

Jurisdiction	Non-English Speaking	Disabled	Over Age 65	Poverty	K-12 Students	Homes Over 40 Years Old
King County	5.4%	16.1%	10.7%	6.4%	16.6%	33.5%
Washington State	14.0%	17.7%	11.2%	10.6%	19.1%	29.4%

Sources: U.S. Census Bureau, Profile of Selected Social Characteristics: 2000, and Profile of Housing Characteristics: 2000.(Washington State figures)
2007 Census Bureau
2008 King County Annual Growth Report

The King County Emergency Coordination Center (ECC) becomes activated for earthquake events to coordinate damage assessment, information, response activities, and to insure continuity of government operations. Response activities include unanticipated overtime for ECC activations, evacuations, sheltering of displaced people, rerouting traffic destined for impassible roads, bridge and road damage repairs, and rescue or medical missions.

Not all earthquake events are eligible for federal assistance to public agencies. For this reason alone, mitigation efforts to minimize the impacts of earthquakes in King County can save a considerable amount of public monies needed to repair damage from modest-sized events. The following list of presidential disaster declarations were associated with listed King County earthquake events above.

Table 5-10: FEMA Earthquake Disasters in King County

FEMA No.	Dates	King County Public Damage (FEMA or Congress Approved)
*	April 1949	$25 Million (1949 dollars)
*	April 1965	$12.5 Million (1965 dollars)
1361	February 2001, Nisqually	$155.9 Million FEMA $84.3 Million SBA $93.8 Million US DOT

**FEMA was established in 1978*

Often, Small Business Administration (SBA) loans are available to individuals and businesses that qualify without a presidential declaration of disaster.

Past Mitigation Efforts

The United States has been a world front-runner in mitigation efforts related to natural disasters. The advent of United States building codes, zoning codes, research on liquefaction areas and ground shaking, building retrofitting, non-structural mitigation/tie-downs, public education, drop-cover-and-hold exercises, and public television specials have dramatically reduced the impact to property, injuries and economic damage. When the United States is compared to countries that do not have these codes and standards (e.g., Turkey, Iran, China, and Pakistan) the earthquake disaster results are dramatically different.

Earthquake Endnotes:

[1] *Washington State 2001 Hazard Identification and Vulnerability Assessment*, Washington State Military Department, Emergency Management Division, April 2001.
[2] Ibid.
[3] *Late Holocene displacement on the Southern Whidbey Island fault zone, northern Puget lowland, Washington*. 2001. U.S. Department of the Interior, U.S. Geological Survey. 2 Oct. 2003 http://earthquake.usgs.gov/research/external/reports/00HQGR0067.pdf
[4] *Earthquake Hazards in Washington and Oregon – Three Source Zones*. U.S. Department of the Interior, U.S. Geological Survey. 2 Oct. 2003 http://www.ess.washington.edu/SEIS/PNSN/CascadiaEQs.pdf.
[5] *Earthquakes in Washington*. 13 Jul. 2001. Washington State Department of Natural Resources Division of Geology and Earth Resources. 5 Oct. 2003 http://www.dnr.wa.gov/ResearchScience/GeologyEarthSciences/Pages/Home.aspx
[6] *Earthquake Hazards in Washington and Oregon – Three Source Zones.* U.S. Department of the Interior, U.S. Geological Survey. 2 Oct. 2003 http://www.ess.washington.edu/SEIS/PNSN/CascadiaEQs.pdf.
[7] *Map and List of selected significant quakes in WA and OR*. 27 Mar. 2003. The Pacific Northwest Seismograph Network, University of Washington Department of Earth and Space Sciences. 5 Oct. 2003 http://www.ess.washington.edu/SEIS/PNSN/INFO_GENERAL/hist.html.
[8] *Earthquake History of Washington*. 5 Aug. 2003. U.S. Department of the Interior, U.S. Geological Survey. 5 Oct. 2003 http://neic.usgs.gov/neis/states/washington/washington_history.html.
[9] *Hazard Mitigation Survey Team Report, Nisqually Earthquake, February 28, 2001, DR-1361-WA*, Federal Emergency Management Agency and Washington Military Department, Emergency Management Division
[10] *The Nisqually Earthquake of 28 February 2001, Preliminary Reconnaissance Report*, Nisqually Earthquake Clearinghouse Group, University of Washington, March 2001.
[11] Preliminary Estimates of Damages and Loss from a run of HAZUS 99-SR2 by Kircher Associates Consulting Engineers for the Seattle Fault Scenario project funded in part by the EERI Foundation, May 2003. The figures developed from a Level 1 analysis of HAZUS default data adjusted for the year 2005 for a five county region – King, Kitsap, Pierce, Snohomish, and Thurston Counties.
[12] *HAZUS 99 Estimated Annualized Earthquake Losses for the United States*. Feb. 2001. Federal Emergency Management Agency. 5 Oct. 2003 http://74.125.153.132/search?q=cache:zaAkt9vt_A8J:www.fema.gov/library/file%3Bjsessionid%3D525D76909AFEB6B3BE783797F93F38E6.WorkerLibrary%3Ftype%3DpublishedFile%26file%3Dfema_366.pdf%26fileid%3D4a624f30-2162-11db-85a2-000bdba87d5b+HAZUS+99+Estimated+Annualized+Earthquake+Losses+for+the+United+States&cd=2&hl=en&ct=clnk&gl=us&client=firefox-a
[13] *2000 Census P.L. 94-171 Restricting Data*. Aug. 2001. Puget Sound Regional Council. 5 Oct. 2003

Attachment A
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Earthquake
Peak Ground Acceleration
100-year Probabilistic Scenario

Mercalli Scale - Potential Damage

- VI - None to Slight
- VII - Slight to Moderate

Note: The scenarios represented in the following maps represent the best available data at the time of this plan update. These are estimates of the impacts of a scenario event that include many assumptions. Scenario maps are constantly being updated by experts in the field of seismology. All future updates of this plan will take into consideration any new data that becomes available that accurately reflect the risk associated with in the planning area.

King County GIS
US Geological Survey
Washington State Department of Natural Resources, Division of Geology and Earth Resources
HAZUS-MH MR3

October 2009
Tetra Tech, Inc.

0 5 10 20 Kilometers

0 5 10 20 Miles

N
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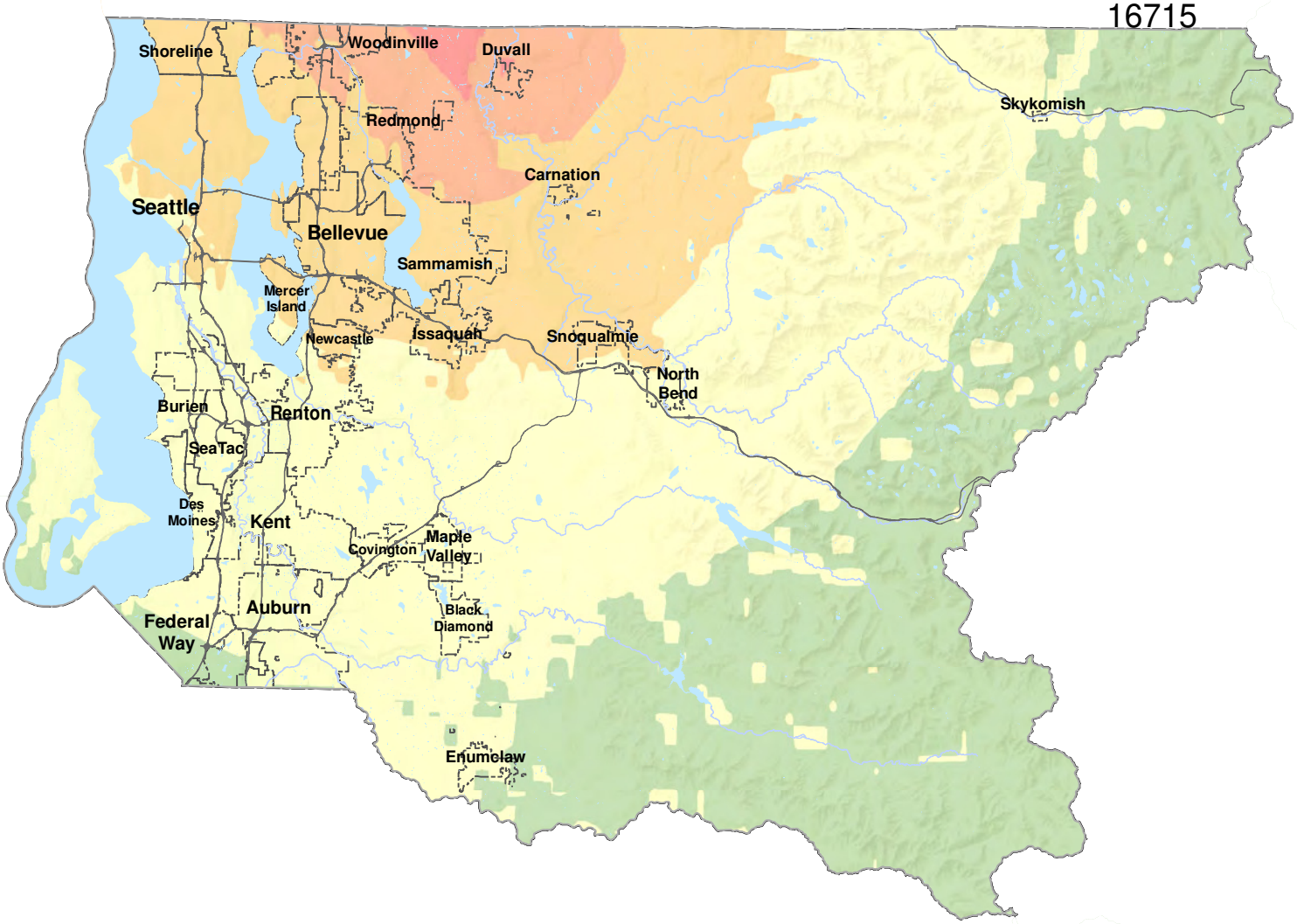
King County

Attachment A
16715



South Whidbey Fault
Peak Ground Acceleration
7.4 Magnitude Scenario Shakemap

Mercalli Scale, Potential Damage

- IV, None
- V, Very Light
- VI, None to Slight
- VII, Slight to Moderate
- VIII, Moderate to Extensive
- IX, Extensive to Complete

Magnitude: 7.4
Depth: 0.0km
Epicenter: N48.05 W122.47
Appx. 2mi NE of Langley, WA

The South Whidbey Fault extends from Victoria BC southeast towards south Whidbey Island. It crosses through Mukilteo and north Woodinville, and possibly extends into eastern Washington.

King County GIS
USGS April 2009 South Whidbey Fault Planning Scenario
Washington State Department of Natural Resources, Division of Geology and Earth Resources

October 2009
Tetra Tech, Inc.

0 5 10 20 Kilometers
0 5 10 20 Miles

N W E S

King County

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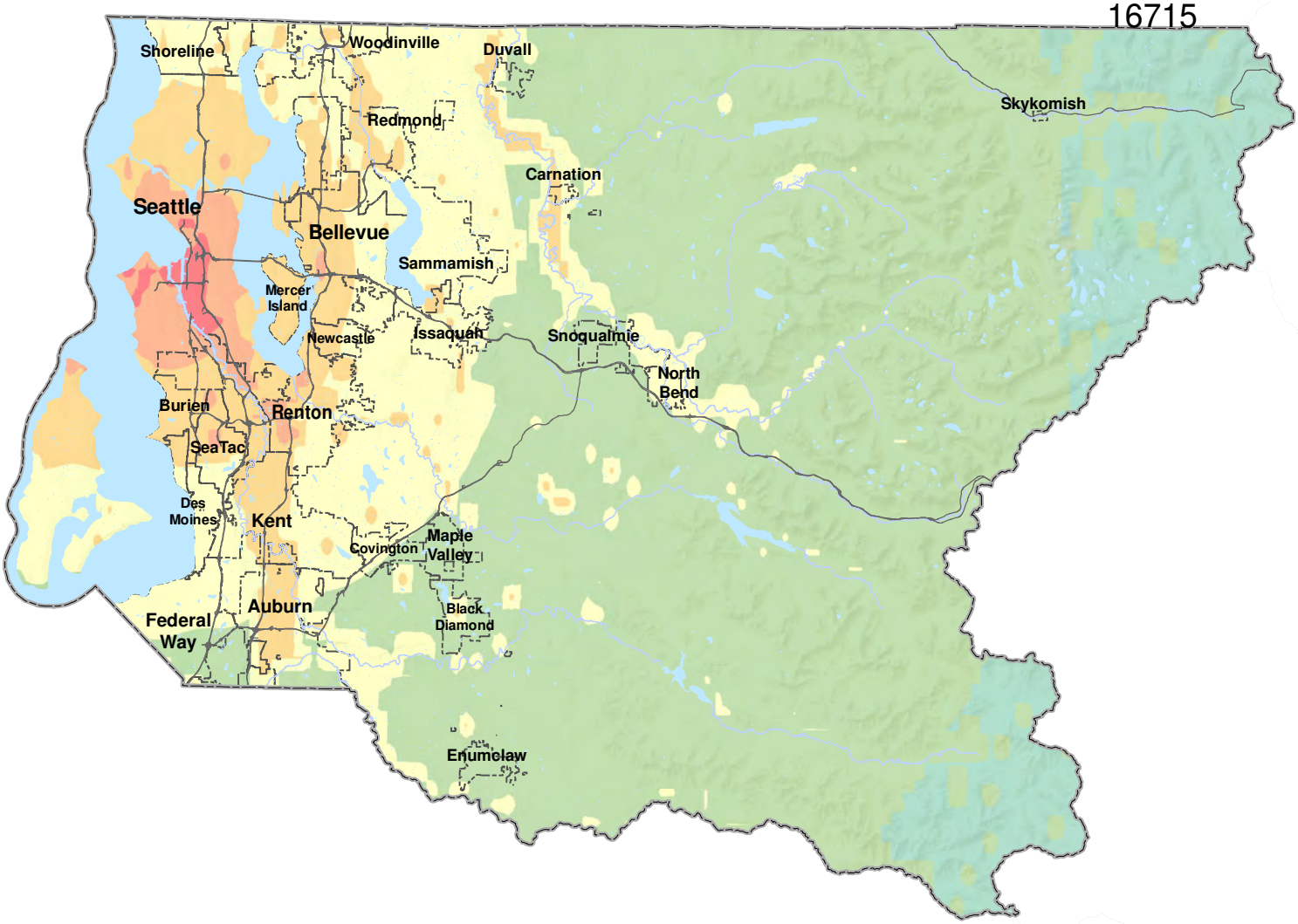


Seattle Fault
Peak Ground Acceleration
6.8 Magnitude Scenario Shakemap

Mercalli Scale - Potential Damage

- IV - None
- V - Very Light
- VI - None to Slight
- VII - Slight to Moderate
- VIII - Moderate to Extensive
- IX - Extensive to Complete

King County GIS
USGS January 2000 Seattle Fault Planning Scenario
Washington State Department of Natural Resources, Division of Geology and Earth Resources

October 2009
Tetra Tech, Inc.

0 5 10 20 Kilometers

0 5 10 20 Miles

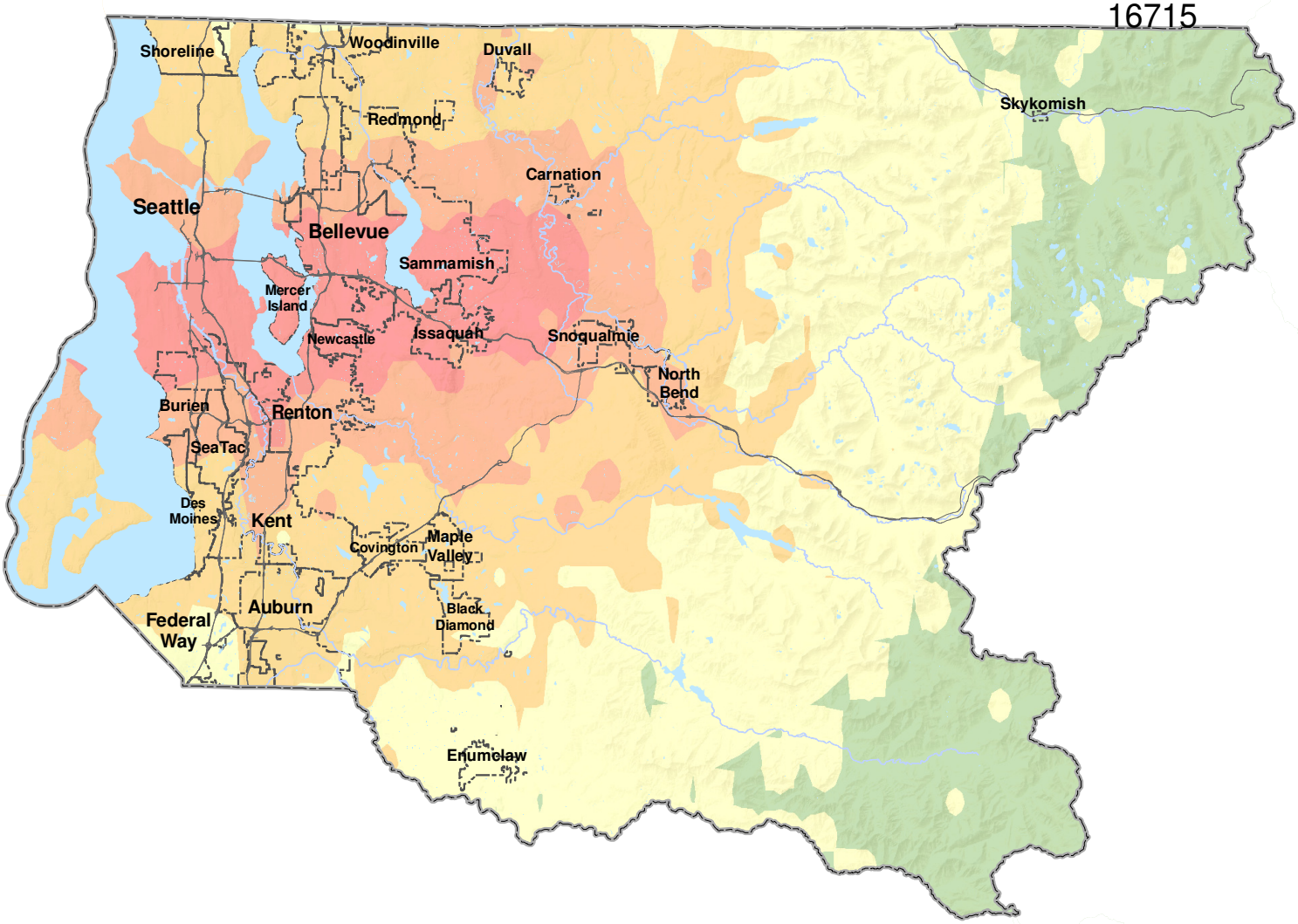
N W E S

Magnitude: 6.8
Depth: 10.0km
Epicenter: N47.60 W122.57
Appx. 10mi W of Seattle, WA

The Seattle fault is a zone of thrust or reverse faults that strikes through downtown Seattle in the densely populated Puget Lowland of western Washington. Analysis of seismic profiles extending 50 km across the Puget Lowland from Lake Washington to Hood Canal indicates that the west-trending Seattle fault comprises a broad (4-6 km) zone of three or more south-dipping reverse faults.

King County

Attachment A
16715



Seattle Art Scenario
Peak Ground Acceleration
7.2 Magnitude Scenario Shakemap

Mercalli Scale, Potential Damage

- V, Very Light
- VI, None to Slight
- VII, Slight to Moderate
- VIII, Moderate to Extensive
- IX, Extensive to Complete

Magnitude: 7.2
Depth: 10.0km
Epicenter: N47.60 W122.57
Appx. 10mi W of Seattle, WA

King County

King County GIS
US Geological Survey Jan. 2000 Seattle Art Shakemap Scenario
Washington State Department of Natural Resources,
Division of Geology and Earth Resources

October 2009
Tetra Tech, Inc.

0 5 10 20 Kilometers
0 5 10 20 Miles

N W E S

Attachment A
16715

National Earthquake Hazard Reduction Program (NEHRP) Soil Site Classes

- Site Class F - Requires site-specific investigation
- Site Class E - Soft Soil
- Site Class D - Stiff Soil
- Site Class C - Very Dense Soil and Soft Rock
- Site Class B - Rock
- Water
- Ice

King County GIS
US Geological Survey
Washington State Department of Natural Resources, Division of Geology and Earth Resources

October 2009
Tetra Tech, Inc.

0 5 10 20 Kilometers

0 5 10 20 Miles

N W E S

King County

Attachment A
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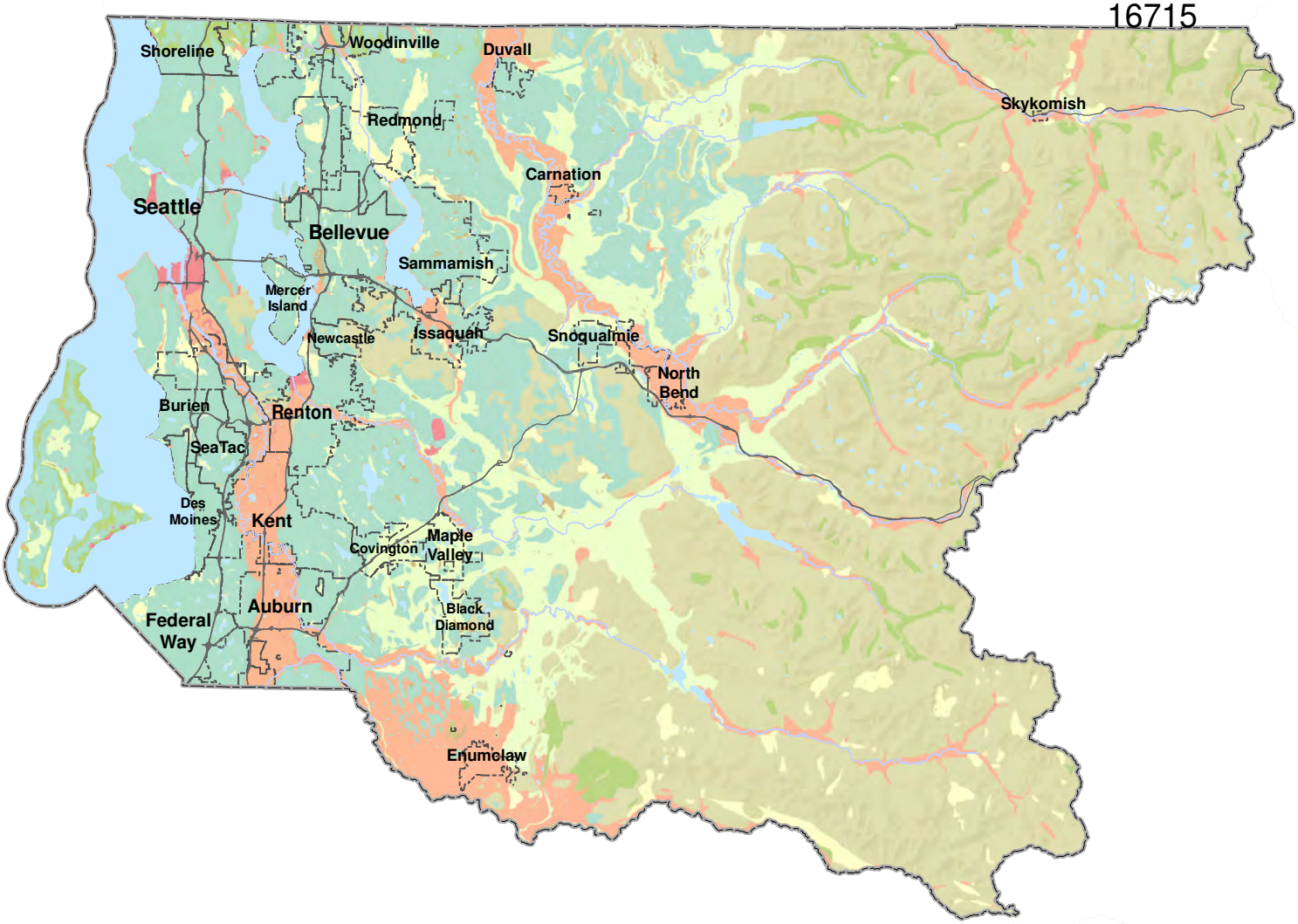

Liquefaction Susceptibility

Liquefaction Susceptibility

- High
- Moderate to High
- Moderate
- Low to Moderate
- Low
- Very Low to Low
- Very Low

Not Susceptible to Liquefaction

- Bedrock
- Peat
- Water
- Ice

King County GIS
US Geological Survey
Washington State Department of Natural Resources, Division of Geology and Earth Resources

October 2009
Tetra Tech, Inc.

0 5 10 20 Kilometers

0 5 10 20 Miles

N
W E
S

King County

One substantive addition for 2009

Introduction

Our country's history has many examples of civil disorder (unrest) associated with demands for political reform. The modern civil disturbance has become increasingly associated with sports events and issues unrelated to political positions. Civil disorders have become a part of the urban environment in Washington State. "Riots" can now generally be classified as either being politically motivated or spontaneously erupting around another event. The most important characteristic of civil disorders is an association with property damage and clashes with law enforcement and authorities.

High Probability Low Impact	**High Probability Moderate Impact**	**High Probability High Impact**
Moderate Probability Low Impact	**Moderate Probability Moderate Impact**	**Moderate Probability High Impact**
Low Probability Low Impact	**Low Probability Moderate Impact**	**Low Probability High Impact**

Civil Disorder Probability and Civil Disorder Impacts

Hazard Identification

In the 1960's civil unrest was focused on civil rights. The Watts riots in Los Angeles left 34 people dead. Similar events occurred in Newark New Jersey with similar results.

In recent years, civil disorder typically begins as nonviolent gatherings. Injuries are usually restricted to police and individuals observed to be breaking the law. Crowds throwing bottles, rocks, and other projectiles are usually responsible for the majority of law enforcement injuries. Injuries to protestors, demonstrators, or law breakers are often the result of efforts to resist arrest, exposure to tear gas or mace, attempts to strike a police officer or from other civilians and law breakers.

Political demonstrations that become civil disorders or riots have specific targets for their attention. Examples would be protests outside a national embassy, city hall, or federal building. These incidents are typically marked by efforts by organizers to obtain permits to demonstrate and are nonviolent in nature. Occasionally, these demonstrations become violent when triggered by some other event. Often, out-of-town agitators are the catalyst for these violent

outbreaks. In the Pacific Northwest, groups with such notoriety are the Skinheads, White Supremacists, and Anarchists.

Celebrations resulting from outcomes of sporting events and annual holiday celebrations occasionally evolve into violence. The central characteristic of these "riots" have been related to substance abuse and consumption of alcohol. Incidents of this type are common in other parts of the world following soccer matches. In the United States, civil disturbances have come to be anticipated following basketball championships (Chicago Bulls, 1991 and 1992; Detroit Pistons, 1990; and recently the LA Lakers, 2001).

Police continue to use variations of riot tactics common for over a hundred years: horse-mounted police and officers on foot with riot shields and batons. Arrests are made of key violent individuals. The 1960s saw the advent of the use of tear gas, also known as CS. There has been an evolution of tactics used by demonstrators and agitators that has resulted in an increasingly complex confrontation/interface between local officials and civilians.

Sophisticated communications capabilities are now available for retail purchase. Radios and "police scanners" have made it possible for demonstrators to organize their efforts and counter law enforcement tactics. This was seen during the World Trade Organization (WTO) disturbances in Seattle, 1999. Members of one group intercepted police tactical communications and broadcast the information over the Internet. One group transmitted over an illegal FM station. The result has been an increase in the integration of efforts between federal agency officials from the Federal Communications Commission and the Federal Bureau of Investigation with local law enforcement.

History of Events

Rodney King Verdict

Following the 1992 Rodney King verdict in California, some local disturbances occurred in Seattle. The night of the verdict, small groups of people roamed the downtown streets smashing windows, lighting dumpsters on fire, and overturning cars. The next day, there was a rally at the Jackson Federal Building in Seattle. Many people feared violence and avoided the downtown area. After the rally broke up, small groups moved around downtown, eventually attacking the Seattle West Precinct on Capitol Hill. Another protest occurred in the University District of Seattle. This event, though peaceful, shut down Interstate-5 to traffic for some time.

WTO and N30, and other World Summits

The best known civil disturbance in King County occurred in conjunction with the World Trade Organization's (WTO) meeting in Seattle during November of

1999. The week-long event found Seattle as the meeting place for world economic leaders and political figures. The world stage event provided an opportunity for activists to gain media attention for their multiple causes ranging from labor reform to environmental exploitation concerns. Similar WTO meetings have occurred in other places around the world with demonstrations that sometimes became violent. Preparations made by local officials proved inadequate to contend with the civil unrest that followed. This event was marked by the presence of many Oregon-based antagonist groups, most notably the "Anarchists."

"N30" was the first anniversary of the WTO riots. Some protestors did appear, but improvements in intelligence, police staffing and staging, use of secure radio frequencies, and briefing of elected officials resulted in a considerably more subdued event.

World summits such as G-8 or APEC have been recognized as world stage international events that can bring in large numbers of protesters.

Mardi Gras Melee[1,2]

This annual Mardi Gras celebration event in Seattle's Pioneer Square has become problematic over the years. In 2001, Mardi Gras celebrations became violent with one man being beaten to death during a violent confrontation involving intoxicated young people in the Pioneer Square area of Seattle. There was some indication the beating may have been racially motivated and gang-related. There were 43 arrest, seven officers injured, and thousands of dollars of damage done to six businesses. There was considerable news coverage of the event and subsequent legal proceedings. Following the incident however, the Supreme Court ruled in 2002 that people could not be found guilty of murder having not intended to kill an individual they've assaulted. The ruling left over 300 suspects in the 2001 riots free from murder convictions, including Jerell Thomas whom was convicted of killing Kristopher Kime during the unrest.[7]

For the 2009 Mardi Gras event, Seattle's police department employed the usage of wireless live video feed to monitor several public locations, in hopes of more timely response and more efficient utilization of police personal.[8]

Additional Interstate-5 Closures

The closure of Interstate-5 to traffic by illegal protest marchers has become somewhat of a traditional expression by individuals opposing social or political events. In April 2002, a King County Deputy shot a suspect. That month protestors caused temporary closure of Interstate-5.[3] Again on September 30, 2002, street marchers mingled peacefully with sports enthusiasts in downtown

Seattle. At the outbreak of hostilities regarding the war in Iraq in February 2003, this same disruption of I-5 transportation and commerce was repeated.

University of Washington Violence

In 2003, a recent outburst by drunken youths in the University of Washington fraternity district resulted in overturned burning vehicles and injured people. While only one person was arrested, non-college outside agitators were suspected of instigating the incident.

Hazard Impacts

The economic impact to urban areas during civil unrest and following such events can be profound. Direct impacts include looting and smashed windows as well as endangering shop owners and customers. Indirect economic impacts result from the loss of business when potential customers do not approach businesses for extended periods of time. Customer impressions and habits can change from the experience of a single threatening event. In Seattle, WTO resulted in the closure of several small businesses in the downtown core, resulting in a cry from shop owners to visibly increase protection of their properties. Largely, Mayor Paul Schell lost his re-election bid because of the City's handling of the event.

Thousands of political demonstrations occur each year nationally without major incidents, injuries, property damage or arrests. The right to protest peacefully is a hallmark of our nation's liberties handed down to us from the 18th century.

Table 5-11: Civil Disorder Costs

Event Date(s)	Area	King County Damage Dollars
Rodney King Verdict[3]	Seattle/King County	150 arrests 5 major fires Looting, property damage
WTO-N30 Nov 1999, 2000[4]	Downtown Seattle & Capital Hill	$1.5 M police costs, $7 M in lost retail sales 250+ arrests 120+ injuries
Mardi Gras- February 28, 2002[1]	Pioneer Square – Seattle	1 person killed 6 police injured, 69 people 43 arrests
A20 Event – April 2002[5]	Capitol Hill, Westlake Mall, Seattle Central Community College	19 arrests Nominal property damage

I-5 closures – protest marches[6]	University of Washington to Downtown – Seattle	Nominal damage
University of Washington Campus 10/03	University of Washington Campus Fraternities	Police cruisers and civilian vehicles damaged and burned
Mardi Gras events annually 2003 - 2006	Pioneer Square – Seattle	2002, 2009 Legislation imposed because of annual events [7,8]

Past Mitigation Efforts

Law enforcement surveillance and counter intelligence units are becoming common place in major cities around the United States. Intelligence sharing efforts between national agencies and local officials is improving. The controversial Patriot Act and civil rights issues have become part of the landscape of police efforts to minimize exposure to violent civil disturbances. Police in urban areas continue to explore training opportunities and consider tactical changes in their planning for such expected and unscheduled events.

Local merchants have installed monitoring cameras in the Pioneer Square area to reduce the attraction to anonymous violence and illegal activity.

Civil Disorder (Unrest) Endnotes:

[1] Tracey Johnson, "Police charges won't be filed against teen arrested in melee", Seattle Post Intelligencer, May 26th, 2001, www.Seattle PI.NWsource.com/specials/mardigras
[2] Candy Hatcher, "Thousand of dollars claimed by 6 Businesses", Seattle Post Intelligencer, February 28th, 2001
[3] Vanessa Ho and Hector Castro, "10 years after Rodney King, the issues very much with us", Seattle Post Intelligencer, April 29th, 2002
[4] Murakami, Kerry. "Seattle Saddled with Millions in WTO Bills." Seattle PI, NW Source (200) October 14, 2003
[5] Mike Roarke & Lewis Kamb, "Police Arrests as hundreds march on downtown streets", Seattle Post Intelligencer, April 20th, 2002
[6] Jeffrey Barker, "Thomas Rally intrigues some, puzzles others", Seattle Post Intelligencer, September 30, 2002
[7] Tracy Johnson, "10 years for 2001 Mardi Gras riot killing", Seattle Post Intelligencer, Feb 28, 2009 http://www.seattlepi.com/local/261101_thomas28.html
[8] "Seattle Police Department Monitors Mardi Gras Festivities With Wireless Video Surveillance" Reuters, March 24, 2009 http://www.reuters.com/article/pressRelease/idUS140618+24-Mar-2009+PRN20090324

No substantive changes made for 2009

Introduction

Terrorism has been defined by the Federal Bureau of Investigation as "the unlawful use of force or violence against persons or property to intimidate or coerce a government, the civilian population, or any segment of it in furtherance of political or social objectives." More importantly, it is necessary to understand that the objective of terrorism is not destruction or death – it is the psychological impact to the targeted population and world opinion. Disruption to public services, economies, and social patterns or a feeling of insecurity is the desired goal.

High Probability Low Impact	**High Probability Moderate Impact**	**High Probability High Impact**
Moderate Probability Low Impact	**Moderate Probability Moderate Impact**	**Moderate Probability High Impact**
Low Probability Low Impact	**Low Probability Moderate Impact**	**Low Probability High Impact**

Terrorism Probability and Terrorism Impacts

Hazard Identification

Terrorism can be categorized as either domestic or international. Domestic terrorism incidents are acts conceived of and carried out by U.S. citizens within the U.S. borders. Examples of domestic terrorism include environmental groups like the Animal Liberation Front (ALF), groups opposing abortion, animal rights groups opposing the fur trade, or the Oklahoma City bombing of the Murrah Building.[1] Each year King County Police receives calls related to hundreds of bomb threats. International terrorism originates from groups based outside the U.S.A. and may be perpetrated against U.S. interests abroad or within the territorial boundaries of the U.S.A. Examples would be Al Quada and sympathizer groups.

Terrorist targets tend to be located in urban areas. Seats of government, stadiums and public meeting places are high-value targets that produce substantial news coverage. Contrary to this, there is some evidence that terrorist organizations prefer rural safe houses from which to operate. The rural environment offers an environment that is more difficult to observe.

On a worldwide basis, explosive and small arms remain the primary method of aggression. Domestically, this theme was evident in the shoe bomber incident (Richard Reid),[2] Washington, D.C. shootings,[3] Twin Trade Towers, University of

Washington School of Horticulture bombing, Atlanta Olympics bombing,[4] and Atlanta abortion clinic bombing. Officials are increasingly concerned about the use of weapons of mass destruction on U.S. soil. Concern for this possibility began to grow with the disintegration of the Soviet Union. At that time the Soviet military acknowledged it could not account for many "suitcase" or portable nuclear devices.

Weapons of Mass Destruction (WMD) can be categorized as belonging to one or more of the following groups: chemical, biological, radiological, nuclear or explosive. Incendiary devices and cyber terrorism can also be added to this list. Title 18, U.S.C. 2332a, includes the accepted definition for weapons of mass destruction in the United States:

> "(1) any destructive device as defined in section 921 of this title [which reads] any explosive, incendiary, or bomb, grenade, rocket having a propellant charge of more than one quarter ounce, mine or device similar to the above; (2) poison gas; (3) any weapon involving a disease organism; or (4) any weapon that is designed to release radiation or radioactivity at a level dangerous to human life."

The concept of using chemical weapons is based on the field of toxicology. As such, chemical weapons are comprised of a fairly large, growing and creative list of materials that can kill humans or pollute the environment. While listed as a weapon of mass destruction, typical chemical weapons do not destroy property – rather, they deny the use of the area of distribution or scatter through persistence of a difficult to clean up chemical. In this way, chemical, radiological and biological terrorist weapons are similar. Military chemical weapons are designed to be used in battlefield conditions against combatants. Their persistence or impact is of short duration (hours or days) to allow occupation of some strategic area by friendly forces.

In many ways the common components used to make chemical weapons are similar to those used for industrial, commercial and agricultural purposes, although with a destructive intent and outcome involved. Chemical weapons began as industrial materials with military applications. They have been used in organized military programs since the Germans used chlorine and arsine in World War I. The list expanded to the use of nerve agents like sarin and tabin when it was realized that insecticides could effectively be used against human targets.

Radiological materials are very similar to chemical materials. They usually do not kill humans outright. Exposure to such a dose would require very large amounts of radioactive material at fairly close range. While the time required for a material to decay and render itself inert varies widely, many materials can

persist in the environment for years to centuries at levels that can impact humans and the environment.

The usefulness of radioactive materials to the terrorist is derived from long-term exposures to moderate amounts of radiation and the difficulty in cleanup of the impacted area. Like chemical and biological agents, radioactive materials can not be observed by a civilian. For this reason they instill a significant psychological impact to the public.

The Federal Bureau of Investigation defines biological agents as micro organisms or their toxins. The U.S. Code Title 18, Section 178 also provides a broad definition to biological agents. This definition would include viruses, bacteria, spores, and toxic materials given off by these organisms. Commonly, these include the plague, anthrax, smallpox, and other disease organisms.

Natural materials with toxicity to humans are also being used for terrorist activities. Ricin, a toxin derived from Castor beans, has been used as a direct contact poison for assassinations. Another known natural poison is curare. Used for hundreds of years by South American tribes, this material (in smaller doses) has taken a beneficial roll in medicine. The medical profession has a fairly substantial list of these natural occurring materials.

Explosives have been defined by a variety of sources ranging from the fire service to the United States Code. Commonly, these definitions focus on chemical reactions that produce a shock wave and heat. This definition allows the inclusion of nuclear fission devices. These and incendiary devices are truly weapons of mass destruction, their purpose being to cause damage to property as well as injury to people. Definitions of explosives include black powder, pellet powder, initiating explosives, detonators, safety fuses, squibs, detonating cord, igniter cord, and igniters. Incendiary devices include chemicals that may accelerate or initiate fire.

Any individual or combination of the WMD classes listed can be used as booby traps, mines and bombs and can be directly or remotely detonated or initiated.

Increasingly, experts are putting efforts into countermeasures related to cyber terrorism. The global economy's reliance on transactions and communications presents an inviting target to terrorists that can operate in almost any corner of the globe. Terrorists are also likely to use cyber attacks as a force multiplier in a physical incident to impede first responders, spread misinformation, and promote panic in the general populations.

Presidential Decision Directive #39 designates the Federal Bureau of Investigation as the lead agency responsible for terrorism investigations within the borders of the United States and its territories. This lead designation has required a new partnership and increased cooperation between local law

enforcement, federal officials and hazardous materials teams in Washington State.

History of Events and Hazard Impacts

The U.S. population has largely been spared the impacts of international terrorism until recently. The devastation which occurred at the World Trade Center in New York and the Alfred Murray building in Oklahoma City illustrates the need to plan for potential threats within our own communities. Domestically, the distribution of anthrax spores using the United States Postal System as a delivery mechanism caused concern nationwide for several weeks. The bomb detonated at the Atlanta Olympics in (1996) resulted in an investigation/manhunt that lasted years. The Richard Reid (a.k.a. the Shoe Bomber) disrupted air travel and changed security measures in airports; he was sentenced to life in prison.

Washington State and King County locations have witnessed multiple examples of terrorist activity over the last decade. One East Coast incident involved a Tacoma gun shop connection. See the table below for a list of events over the past decade:

Table 5-12: Recent Washington Terrorism-related Events

Type Event	Date	Group	City/ Location	No. of Incidents	Damage or Injuries
Explosive	1993	Skinheads[6]	Tacoma	2	Figures not available
Chemical-Explosive	1995	Unknown[7]	Burien District Court	1	No damage reported
Explosive	Dec 14, 1999	Ahmed Ressam[8]	Port Angeles	1	none
Incendiary	May 2001	ALF	University of Washington	2	$5 M
Biological White Powder	Jan 2000 to Dec 2002	Miscellaneous individuals[9]	Seattle, Federal Way, Tukwila, Port of Seattle, other cities	208	Overtime and service disruption
Fire Arms	Oct 2002	John Allen Muhammad & John Lee Malvo[3]	Washington, DC & Tacoma	13	10 killed, 3 wounded

Past Mitigation Efforts

While some legislation and operational countermeasures have existed for some time, the events of September 11, 2001 have accelerated terrorism mitigation efforts. Broadly, grants have been awarded to local first responders since 1998 for the purchase of important response equipment; national and local exercises of plans a procedures conducted; powers given or broadened for law

enforcement regarding surveillance; and the consolidation of several agencies into the U.S. Department of Homeland Security have been completed. Capabilities related to bioterrrorism have received increasing attention.

Equipment grants for decontamination, detection, and protective gear for first responders have been available to local first responders since 1998. These grants and supplemental grants have provided millions of dollars in increased capabilities. As these capabilities have improved, the definition of first responder has been broadened from fire and police to now include hospital personnel and facilities, public works and emergency medical responders.

In 2000, the U.S. Department of Justice and Office of Domestic Preparedness began a national exercise program to integrate federal, state, and local terrorism response capabilities and elected official preparedness for such events. The TOPOFF (top officials) series began with an exercise involving Portsmouth, New Hampshire and Denver, Colorado. In 2002, this exercise opportunity presented itself to Seattle, King County, and Washington State as well as Chicago, Illinois. Cities and counties in Washington State continue to pursue opportunities to improve response capabilities by conducting additional local exercises and training. It is worth noting that TOPOFF 2 included a multi-jurisdiction cyber exercise involving King County, the City of Seattle, and Washington state business leaders and senior technologists. This forum provided an excellent learning opportunity and helped underscore how dependent business operations are on technology and some of the key vulnerabilities jurisdictions typically face with their technology infrastructure and cyber incident response capabilities.

Beginning in 2002, grants became available from several federal agencies for local jurisdictions to initiate and continue planning, training, equipment purchase, and exercise efforts. Federal funding agencies include Department of Justice, Office of Domestic Preparedness, Centers for Disease Control and Prevention, Transportation Security Administration, Federal Transit Administration and others.

An important step in the efforts to counter terrorism in the U.S. was made with the issue of Presidential Decision Directive #39[10] on June 21, 1995. This directive identified the FBI as the lead agency for terrorism investigation. Subsequent to the events of September 11th, 2001 the U.S. Congress consolidated elements of the U.S. Department of Justice, U.S. Coast Guard, U.S. Immigration, and other agencies into the Department of Homeland Security. The Aviation and Transportation Security Act was passed by Congress on November 19, 2001 giving responsibility for items like airport security to the Transportation Safety Administration.

The USA PATRIOT Act [11,12] contains provisions appreciably expanding government investigative authority, especially with respect to the Internet. The USA PATRIOT Act introduced sweeping changes to U.S. law, including amendments to:

- Wiretap Statute
- Electronic Communications Privacy Act
- Computer Fraud and Abuse Act
- Family Education Rights and Privacy Act
- Pen Register and Trap and Trace Statute
- Money Laundering Control Act
- Bank Secrecy Act
- Right to Financial Privacy Act
- Fair Credit Reporting Act

Other important federal acts and directives include:

- Homeland Security Presidential Directives 1-5

    1. Organization and Operation of the Homeland Security Council
    2. Combating Terrorism Through Immigration Policies
    3. Homeland Security Advisory System
    4. National Strategy to Combat Weapons of Mass Destruction
    5. Management of Domestic Incidents (NIMS-National Incident Management System)

- Presidential Directive #62, Protection against Unconventional Threats to Homeland and Americans Overseas.
- Title 18, USC Section 2332a Weapons of Mass Destruction
- Title 18, USC, Sections 175-178, Biological Weapons Anti-terrorism Act
- H.R. 5005, the Homeland Security Act of 2002

Federal, State, and local cooperation continues to improve relationships, capabilities and innovative methods to mitigate terrorism in the U.S. and impacts to its interests.

Some details of grants, exercises, plans and procedures are not subject to Freedom of Information Act release due to their sensitive or national/domestic security protection.

Terrorism Endnotes:

[1] CNN News, "Oklahoma City Bombing" April 19th, 1995, www.cnn.com/us/okc/bombing.html
[2] BBC News, "Shoebomber Jailed for Life", January 30th, 2003
[3] CNN.com, "Ballistics match rifle to sniper attacks", http://www.cnn.com/2002/US/South/10/24/sniper.shootings/
[4] CNN.com, "Atlanta Olympic Bombing Suspect Arrested", May 31st, 2003
[5] Presidential Decision Directive #39, June 21, 1995, http://www.fas.org/irp/offdocs/pdd39.htm
[6] Washington State Emergency Management Hazard Vulnerability Analysis, 1996
[7] King County Emergency Management, Duty Officer Log, May 1995
[8] Sam Skolink & Paul Shukovsky, "Ressam- Seattle no Target", Seattle PI, May 31st, 2001
[9] Washington State Joint Committee on Terrorism figures, 2003
[10] Presidential Decision Directive #39, http://www.fas.org/irp/offdocs/pdd39.htm
[11] "Uniting and strengthening America by providing appropriate tools to intercept and Obstruct Terrorism Act of 2001", aka the Patriot Act (HR 3162), http://www.epic.org/privacy/terrorism/hr3162.html
[12] Electronic Privacy Information Center, the US Patriot Act (Summary/Brief & Commentary), http://www.epic.org/privacy/terrorism/usapatriot/

2005 History Updated for 2009

Introduction

Western Washington is typically associated with rain, green trees, and healthy environments, making the idea of drought in King County a far-fetched notion. There is a possibility for drought conditions in our area, as exemplified most recently in 2001. As a result, King County residents and employers need to be aware of the hazards presented by drought to our area.

Drought can be a result of multiple causes including "global weather patterns that produce persistent, upper-level high-pressure systems along the West Coast with warm, dry air resulting in less precipitation."[1] Drought may be defined as a prolonged period of dryness severe enough to reduce soil moisture, water and snow levels below the minimum necessary for sustaining plant, animal, and economic systems.[2] While drought isn't typically thought of as a King County hazard, the historical record demonstrates that it is important to consider drought conditions as a potential impact to the region.

High Probability Low Impact	**High Probability Moderate Impact**	**High Probability High Impact**
Moderate Probability Low Impact	**Moderate Probability Moderate Impact**	**Moderate Probability High Impact**
Low Probability Low Impact	**Low Probability Moderate Impact**	**Low Probability High Impact**

Drought Probability and Drought Impacts

Hazard Identification

The National Oceanic and Atmospheric Administration (NOAA) defines drought as less than 60% normal precipitation over a prolonged period of time.[3] However, in Washington State, the statutory criteria for drought is a water supply below 75% of normal and a shortage expected to create undue hardship for some water users.[4]

[1] Washington State Hazard Mitigation Plan, Region 6, http://www.emd.wa.gov/plans/documents/Tab_4_Planning_Process.pdf
[2] Washington State Hazard Mitigation Plan, Region 6, http://www.emd.wa.gov/plans/documents/Tab_4_Planning_Process.pdf
[3] Pierce County Hazard Identification and Vulnerability Assessment, http://www.co.pierce.wa.us/xml/abtus/ourorg/dem/EMDiv/HIVA/DROUGHT.pdf
[4] Washington State Comprehensive Emergency Management Plan Annex Z2, Drought Contingency Plan, http://www.drought.unl.edu/plan/state%20plans/WAplan.pdf

Assessing the probability of drought conditions in King County can be challenging, due to the temperate weather nature of our region. As a result, current long-range forecasts of drought have limited reliability. Meteorologists do not believe that reliable forecasts are attainable any more than a season in advance.[5] If historic patterns repeat themselves, dry conditions occur approximately every decade. Probability of Drought conditions is Moderate – the potential Impact from Drought conditions is Moderate. See table 5 – 13.

Drought conditions can be described in the following four ways:

Meteorological: a measure of departure of precipitation from normal. Due to climate differences what is considered a drought in one location may not be a drought in another.

Agricultural: refers to a situation when the amount of moisture in the soil no longer meets the needs of a particular crop.

Hydrological: occurs when surface and subsurface water supplies are below normal.

Socioeconomic: refers to the situation that occurs when physical water shortage begins to impact people's jobs, incomes, recreational capabilities and other such factors.

The severity of drought is measured by the Palmer Drought Severity Index in a range of 4 (extremely wet) to –4 (extremely dry), and incorporates temperature, precipitation, evaporation and transpiration, runoff and soil moisture when designating the degree of drought.[6]

Table 5-13: Palmer Drought Severity Index Classifications

4.0 or more	Extremely Wet
3.0 to 3.99	Very Wet
2.0 to 2.99	Moderately Wet
1.0 to1.99	Slightly Wet
0.5 to 0.99	Incipient Wet Spell
0.49 to -0.49	Near Normal
-0.5 to 0.99	Incipient Dry Spell
-1.0 to –1.99	Mild Drought
-2.0 to –2.99	Moderate Drought
-3.0 to –3.99	Severe Drought
-4.0 or less	Extreme Drought

Source: Pierce County Emergency Management Hazard Identification and Vulnerability Assessment 2002

[5] Washington State Hazard Mitigation Plan, Region 6, http://www.emd.wa.gov/plans/documents/Tab_4_Planning_Process.pdf

[6] Governor's Ad Hoc Executive Water Emergency Committee Staff, "History of Drought in Washington State", State of Washington, December 1977, p 7.

In 1989, the Washington State Legislature gave permanent drought relief authority to the Department of Ecology and enabled them to issue orders declaring drought emergencies. (RCW 43.83B.400-430 and Chapter 173-166 WAC).[7]

In comparison to other natural disasters that may occur in Western Washington, drought doesn't usually result in property damage or loss of life, although it can have substantial negative impact on the environment and economy.

History of Events

Every few years in Washington State, drought conditions are present with an inherent impact of moderate on the Palmer Drought Severity Index. In the last century in Washington State, there have been a number of drought episodes, including several that have lasted for more that a single season, including dry periods occurring between 1928-1932 and 1992-1994.

However, King County experiences drought conditions of at least moderate severity in classification from 5 to 10 percent of the time, evidenced most prominently during our most recent severe drought periods in 1977 and 2001. The 1977 event set records for low precipitation, snow-pack, and stream flow totals that still stand today, while the 2001 event was the second-worst drought year in state recorded history.[8]

1977 Drought: King County experienced severe or extreme drought conditions between 10-20 percent of the time.

2001 Drought: At the height of this event in March 2001, King County experienced moderate to severe drought conditions.[9]

Rainfall for Western Washington during the 2001 water year was approximately 30% below normal. On March 14, 2001, after several months of record low precipitation, Governor Gary Locke authorized the Department of Ecology to declare a statewide drought emergency. Washington was the first Northwest state to make a drought declaration. Due to above-average precipitation during the final two months of the year, the drought emergency formally expired on December 31,

[7] Skagit County Natural Hazards Identification Plan, http://www.skagitcounty.net/EmergencyManagement/Documents/2003HazMitFinal/Section%20II%20Final%20Documents/3%20HIVA%20Skagit%20Drought.pdf
[8] Skagit County Natural Hazards Identification Plan, http://www.skagitcounty.net/EmergencyManagement/Documents/2003HazMitFinal/Section%20II%20Final%20Documents/3%20HIVA%20Skagit%20Drought.pdf
[9] Washington State Hazard Mitigation Plan, Region 6, http://www.emd.wa.gov/plans/documents/Tab_4_Planning_Process.pdf

2001. The National Weather Service reported that the winter of 2000-01 was the driest since 1976-1977, and was one of the top five driest in the past 100 years.[10]

Table 5-14: Drought History

Year	Conditions	Causes
2005	Water Shortage, March March 21, County Executive News Release; KC Drought Response Plan Activated	Record Low Precipitation, low snowpack, low river levels
2001	Moderate to Severe Drought, Statewide	Low precipitation
1988	Water Shortage; Water Shortage	Level of Chester Morse Lake fell below outlet; Tolt Pipeline broke during peak usage
1987	Water Shortage; Water Shortage	Tolt Pipeline broke Hot, dry summer weather increased water demands beyond limits
1977	Severe to Extreme Drought	Low precipitation
1967	Water Shortage	Dry summer
1965-66	Water Shortage	Dry throughout state
1952-53	Water Shortage	Lack of winter precipitation
1928-30	Statewide Drought	Rainfall was 20% of normal
1919	Water Shortage	Dry summer

Source: City of Seattle Emergency Management Disaster History

Hazard Impacts

Drought conditions occurring in King County can have an impact on the economic viability of agriculture and power-related industries as well as water and snow-related recreational activities. Drought conditions would impact the amount of water available for crops grown for commercial and domestic use, and could also reduce the snow pack available in our local mountain passes, which could have a negative result on area winter sports tourism.

Additionally, due to the prevalence of hydroelectric dams in King County, drought conditions could also have a negative impact on the availability and cost of electric power for local businesses and industries. When water levels drop, electric

[10] Skagit County Natural Hazards Identification Plan, http://www.skagitcounty.net/EmergencyManagement/Documents/2003HazMitFinal/Section%20II%20Final%20Documents/3%20HIVA%20Skagit%20Drought.pdf

companies cannot produce enough power to meet demand and are forced to buy electricity from other sources.[11]

Additional impacts to King County industry may include a negative impact on the capabilities of firefighters in the area, as water shortages may result in reduced water flow and pressure available to combat wild land and structural fires that may take place in our region.

Past Mitigation Efforts

Efforts to mitigate the effects of drought conditions in our area include consistent vigilance of forecasted conditions like the prevalence of rainfall, or the amount of snow pack present in the mountain passes.

Additional efforts include King County's Regional Wastewater Services Plan, a 30-year operating plan for our wastewater system that calls for expanding the production and use of reclaimed water as a valuable resource. Reclaimed water is wastewater that gets treated to such a high level that it can be used safely and effectively for non-drinking water purposes such as landscape and agricultural irrigation, heating and cooling, and industrial processing. Reclaimed water has been used successfully and safely in other areas of the country and world for decades, and is a viable tool to utilize when combating drought in King County.[12]

Other mitigation efforts include sustainable landscaping, a low maintenance method of outdoor design featuring native plants that promotes healthy soil, minimizes water use, and doesn't need excessive fertilizer or pesticides.[13]

[11] King County Office of Emergency Management Drought Resource Section, http://www.kingcounty.gov/safety/prepare/residents_business/Hazards_Disasters/Droughts.aspx
[12] King County Water Reuse Program, http://www.kingcounty.gov/environment/wastewater/ReclaimedWater.aspx
[13] King County Solid Waste Division, Sustainable Landscaping, http://www.metrokc.gov/dnrp/swd/sustainable-landscaping/index.asp

One substantive addition made for 2009

Introduction

Fires don't generally call for region wide attention unless the fire migrates to adjoining buildings, homes, or property or is determined to have the potential to do so. Fast-spreading structure fires can quickly threaten a large amount of people, as well as tax the resources of local fire-fighting jurisdictions

King County is at risk for three types of fire threats: structure, wildland, and wildland-urban interface fires. These threats are typically defined as:

Structure Fire**:** a fire of natural or human-caused origin that results in the uncontrolled destruction of homes, businesses, and other structures in populated, urban or suburban areas.

Wildland Fire**:** a fire of natural or human-caused origin that results in the uncontrolled destruction of forests, field crops and grasslands.[14]

Wildland-Urban Interface**:** a fire of natural or human-caused origin that occurs in or near forest or grassland areas where isolated homes, subdivisions, and small communities are also located. [15]

High Probability Low Impact	**High Probability Moderate Impact**	**High Probability High Impact**
Moderate Probability Low Impact	**Moderate Probability Moderate Impact**	**Moderate Probability High Impact**
Low Probability Low Impact	**Low Probability Moderate Impact**	**Low Probability High Impact**

Fire Hazards Probability and Fire Hazards Impacts

The Washington Department of Natural Resources and its federal and local partners found that 181 communities were at high risk for fire threats, including some communities housed within the jurisdiction of King County. Communities were evaluated based on fire behavior potential, fire protection capability, and risk to social, cultural and community resources. Assigned risk factors included area fire history, type and density of vegetative fuels, extreme weather conditions,

[14] Sinnett, George M, Meteorologist, Fire Weather Summary, 1983-1991, Department of Natural Resources, Division of Fire Control, Washington State, 1992.
[15] Skagit County Natural Hazards Mitigation Plan
http://www.skagitcounty.net/EmergencyManagement/Documents/2003HazMitFinal/Section%20II%20Final%20Documents/5%20HIVA%20Skagit%20Fire.pdf

topography, number and density of structures and their distance from fuels, location of municipal watershed, and likely loss of housing or business. The evaluation used the criteria in the wildfire hazard severity analysis of the National Fire Protection Association's NFPA 299 Standard for Protection of Life and Property from Wildfire, 1997 Edition.[16]

As a result, fire hazards are a very real risk for King County residents and businesses and must be vigilantly prepared for and mitigated against in efforts to keep our region and surrounding counties and communities safer.

Hazard Identification

A fire needs three elements in the right combination to ignite and grow – a heat source, fuel, and oxygen. How a fire behaves primarily depends on the characteristics of available fuel, weather conditions, and terrain. Fuels can include ignition sources like poor wiring or unattended candles, lighter fuels like grasses and leaves, heavier fuels like tree branches and logs, and hazard trees that may be diseased or dying.[17]

Weather also plays a role in the forms of wind, low precipitation, and lightening. As a result, strong, dry east winds in late summer and early fall can produce extreme fire conditions west of the Cascades. Drought, snow pack, and local weather conditions can also expand the length of the fire season.[18] Additionally, according to data from 1992-2001, lightening ignited 135 wildland fires annually and burned more state-protected acreage than any other cause, an average of about 10,866 acres annually.[19]

Terrain is an additional factor, as the topography of a region or local area influences the amount and moisture of available fuel. Other elements like barriers and land elevation also need to be taken into account as highways and lakes can affect spread of fire, as can an uphill/downhill orientation, as fire spreads more easily as it moves uphill.[20]

In addition to natural conditions for fire viability, humans also play a role. From 1992 to 2001, people, on average, caused more than 500 wildland fires each year

[16] Washington State Hazard Mitigation Plan, Hazard Identification and Vulnerability Assessment on Wildland Fire, http://emd.wa.gov/3-map/mit/mit-pubs-forms/hazmit-plan/Tab%207.1.9%20Wildland%20Fire%20final.pdf
[17] Washington State Hazard Mitigation Plan, Hazard Identification and Vulnerability Assessment on Wildland Fire, http://www.emd.wa.gov/plans/documents/Tab_7_Risk_Assessment_Introduction.pdf
[18] Washington State Hazard Mitigation Plan, Region 6, http://www.emd.wa.gov/plans/documents/Tab_4_Planning_Process.pdf
[19] Washington State Hazard Mitigation Plan, Region 6, http://www.emd.wa.gov/plans/documents/Tab_4_Planning_Process.pdf
[20] Washington State Hazard Mitigation Plan, Hazard Identification and Vulnerability Assessment on Wildland Fire, http://emd.wa.gov/3-map/mit/mit-pubs-forms/hazmit-plan/Tab%207.1.9%20Wildland%20Fire%20final.pdf

on state protected lands. Human caused fires burn an average of 4,404 state-protected acres each year.[21]

Hazard Impacts

Most wildland fires are usually extinguished in their initial stages being less than one acre in area.[22] In fact, Western Washington is less prone to the danger of large or catastrophic wildland fires than the Eastern half of the state. The Western slopes have a shorter fire season, receive more rainfall, have wetter and cooler spring seasons, and are more urbanized.[23] However, these conditions don't make wildland fires any less dangerous, as statistics show that on an annual basis, an average of 905 wildland fires burn 6,488 acres resulting in a resource loss of $2,103,884 in Washington State. [24]

Depending upon temperature, wind, topography, and other factors, wildland fires can spread rapidly and may require thousands of firefighters working several weeks to extinguish.[25] Wildland fires can create their own winds and weather, and generating hurricane force winds of up to 120 miles per hour. Fires can also heat fuels in their path, drying them out, and making them easier to ignite and burn.[26]

With the increasing urbanization of King County, the threat of wildland/urban interface fire grows, due to a rise in the building of vacation homes and the prevalence of more comprehensive transportation systems. King County residents can live outside of crowded city centers while commuting or telecommuting to work. As a result, wildfires can encroach onto residential properties and structure fires can invade wooded areas. These fires are also quite difficult to fight, as the remote locations of residential properties in wooded areas make fire-fighting response times to those areas take longer than normal residential responses. In addition, most fire fighters are trained to fight either wildfires or structure fires, and with only

[21] Washington State Hazard Mitigation Plan, Region 6, http://www.emd.wa.gov/plans/documents/Tab_4_Planning_Process.pdf
[22] Skagit County Natural Hazards Mitigation Plan http://www.skagitcounty.net/EmergencyManagement/Documents/2003HazMitFinal/Section%20II%20Final%20Documents/5%20HIVA%20Skagit%20Fire.pdf
[23] Washington State Hazard Mitigation Plan, Region 6, http://www.emd.wa.gov/plans/documents/Tab_4_Planning_Process.pdf
[24] Skagit County Natural Hazards Mitigation Plan http://www.skagitcounty.net/EmergencyManagement/Documents/2003HazMitFinal/Section%20II%20Final%20Documents/5%20HIVA%20Skagit%20Fire.pdf
[25] Skagit County Natural Hazards Mitigation Plan http://www.skagitcounty.net/EmergencyManagement/Documents/2003HazMitFinal/Section%20II%20Final%20Documents/5%20HIVA%20Skagit%20Fire.pdf
[26] Washington State Hazard Mitigation Plan, Hazard Identification and Vulnerability Assessment on Wildland Fire, http://emd.wa.gov/3-map/mit/mit-pubs-forms/hazmit-plan/Tab%207.1.9%20Wildland%20Fire%20final.pdf

the personal protective equipment (PPEs) for structure fires; and interface fires require both skills, making it difficult to balance the two. [27]

Structure Fires**:** In addition to typical methods of occurrence, structure fires are a potential secondary hazard of earthquakes and riots. One study estimated that 80-100 fires would occur from a large earthquake in the Seattle area.[28] Building codes requiring fire detectors and sprinkler systems are in effect for most large structures, therefore reducing some vulnerability. However, injuries and causalities to structure occupants are the primary concern. These events can also cause the release of hazardous materials as well as disconnect utility lines.

Wildland/Urban Interface Fires: King County is becoming more vulnerable to the effects of wildland/urban interface fires due to increased building, living and recreating in forested areas. The effects of interface fires can be the combined affects of both structure and wildland fires.

History of Events

The largest fire in King County history remains the 1889 Seattle fire, which was estimated to have consumed 60 acres of the downtown area.[29] Also notable was the Blackstock lumberyard fire in 1989 which took the life of one fire fighter and the Mary Pang warehouse fire in 1995 which killed four fire fighters.

In contrast, wildland fires historically, were not considered a hazard, as fire is a normal part of most forest and range ecosystems in the temperate regions of the world, including King County. Fires historically burn on a fairly regular cycle, recycling carbon and nutrients stored in the ecosystem, and strongly affecting the species within the ecosystem. The burning cycle in western Washington is every 100 – 150 years.[30] Controlled burns have also been conducted because the fire cycle is an important aspect of management for many ecosystems. These are not considered hazards unless they were to get out of control. [31]

None of Washington State's most significant wildland fires have occurred in King County, although smaller wildland fires have occurred in the region. All but the Snoqualmie Pass area of King County is part of the South Puget Sound fire protection region of the Washington Department of Natural Resources. During

[27] Washington State Hazard Mitigation Plan, Region 6, http://www.emd.wa.gov/plans/documents/Tab_4_Planning_Process.pdf
[28] McDonald, Terrence J, "Conflagration and Other Large Urban Fires", Seattle: A Hazard Identification and Vulnerability Analysis, Masters Thesis, Cornell University, 1995, p 82.
[29] McDonald, Terrence J, "Conflagration and Other Large Urban Fires", Seattle: A Hazard Identification and Vulnerability Analysis, Masters Thesis, Cornell University, 1995, p 82.
[30] Pierce County Department of Emergency Management Hazard Identification and Vulnerability Assessment Urban/Wildland Interface Fires Section, http://www.co.pierce.wa.us/pc/abtus/ourorg/dem/EMDiv/NaturalHaz.htm
[31] Washington State Hazard Mitigation Plan, Region 6, http://www.emd.wa.gov/plans/documents/Tab_4_Planning_Process.pdf

1992-2001, the South Puget Sound region averaged 182 fires a year that burned an average of 81 acres of state-protected lands.[32]

Past Mitigation Efforts

The Blackstock lumberyard fire fatality resulted in the development of an accountability system called the passport system. This system works with the Incident Command System for tracking the assignments and locations of fire fighters during a response. The system worked so well, that it has been adopted on a national basis for safety improvement on the fire ground. Similarly, the fatalities at the Mary Pang fire have reinforced the continuing need for accountability and safety at a fire scene.

Public education programs are key elements of educating King County residents on indoor and outdoor fire safety, including the importance of fire alarms, extinguishers, fire insurance, and knowledge and understanding of building codes. In efforts to avoid injury or death, residents must plan how to safely exit their home and workplace in the event of a structure fire.

Additionally, effective early fire detection programs and emergency communications systems are essential. Wildland fire prevention education and enforcement programs can reduce the number of wildland fires Washington State faces each year. As a result, the importance of immediately reporting any wildland fire must be impressed upon local residents and visitors utilizing wooded areas. An effective warning system is crucial when needing to notify local residents and visitors in the fire risk area, as well as an evacuation plan detailing primary and alternate escape routes. [33]

The prevention of wildland/urban interface fires, fire-safe development planning requires coordination between county building and transportation planners, to ensure adequate fire escape routes for new sections of development in forested areas. Road closures may also be increased during peak fire periods to reduce access to fire-prone areas. [34] Land use, building codes, mandated sprinkler system installation, vegetation management, survivable materials used in construction of homes, highly trained and equipped fire services and accessibility are all methods used to assist in mitigating urban/wildland fire risk.[35]

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[32] Washington State Hazard Mitigation Plan, Region 6, http://www.emd.wa.gov/plans/documents/Tab_4_Planning_Process.pdf

[33] King County Office of Emergency Management Fire Resource Section, http://www.metrokc.gov/prepare/prepareerespond/hazardsdisasters/firehazards.aspx

[34] King County Office of Emergency Management Fire Resource Section, http://www.metrokc.gov/prepare/prepareerespond/hazardsdisasters/firehazards.aspx

[35] Pierce County Department of Emergency Management Hazard Identification and Vulnerability Assessment Urban/Wildland Interface Fires Section, http://www.co.pierce.wa.us/pc/abtus/ourorg/dem/EMDiv/NaturalHaz.htm

Attachment A
16715

DNR Wildland Urban Interface (WUI) Wildfire High Risk Communities

Wildfire Hazard -
Wildland Urban Interface (WUI)
High Risk Communities

Wildland Urban Interface Areas (WUIs) are shown as defined by the Washington State DNR. Published September 2004, this theme is based on data from the current National Fire Protection Association (NFPA 299) risk assessment, and includes one or several communities with similar wildfire risks.

King County GIS
US Geological Survey
Washington State Department of Natural Resources, Division of Geology and Earth Resources

October 2009
Tetra Tech, Inc.

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King County

Two substantive additions made for 2009

Introduction

Hazardous chemicals are prevalent throughout our society. While industry is the primary user and maintainer of hazardous chemicals, we also have them in our homes, in our cars, at our places of work and recreation. Hazardous materials move through our region on highways, rail lines, pipelines, and by ship and barge through Puget Sound. These major transportation routes are utilized by our trucking industry to transport chemicals not only to local manufacturing plants, but also to businesses and retail outlets. [36]

The geographic and economic characteristics of King County make it likely that hazardous materials releases will occur. Our diverse industrial facilities and transportation routes share space with numerous bodies of waters, wetlands, environmentally sensitive areas, and a multitude of densely populated centers, creating areas of great potential risk for a hazardous materials release.

High Probability Low Impact	**High Probability Moderate Impact**	**High Probability High Impact**
Moderate Probability Low Impact	**Moderate Probability Moderate Impact**	**Moderate Probability High Impact**
Low Probability Low Impact	**Low Probability Moderate Impact**	**Low Probability High Impact**

Hazardous Materials Probability and Hazardous Materials Impacts

Hazard Identification

King County hosts a variety of unique transportation and geographic conditions, including one of the largest deepwater seaports on the west coast, an International Airport in SeaTac that handles cargo from all over the world, as well as fuel pipelines running south from Whatcom County through King County and down into Portland carrying jet fuels, diesel, gasoline, etc. Additionally, local highways like Intertate-5, Interstate-90, US Highway 2, State Route (SR) 18, SR 516, SR 167, US Highway 99 and others transport hazardous materials throughout the region.

In the City of Seattle, there are over 3000 facilities with hazardous materials regulated under the fire code. Other areas with high concentrations of hazardous materials usage include Harbor Island, the Duwamish Corridor, Redmond and the

[36] Pierce County Department of Emergency Management Hazard Identification and Vulnerability Assessment, Technological Hazards Section: Hazardous Materials, http://www.co.pierce.wa.us/xml/abtus/ourorg/dem/EMDiv/HIVA/hazmat.pdf

Kent Valley. Business types that commonly use hazardous materials locally include: hospitals, schools, metal plating and finishing, the aircraft industry, public utilities, cold storage companies, the fuel industries, the communication industry, chemical distributors, research, and high technology firms. Each of these facilities is required to maintain plans for warning, notification, evacuation and site security under various regulations. The majority of releases that occur during the course of regular commerce happen at fixed facilities.

While the majority of incidents tend to involve petroleum products, a significant number involve extremely hazardous materials. Approximately 200 local facilities with extremely hazardous materials report their inventories to the county under SARA Title III provisions. Efforts continue to increase the compliance rate and education level of local facilities. In excess of 300 hazardous materials events require response in King County annually; however, many events are not reported or go undetected.

Hazardous materials may also be released as a secondary result of a natural disaster like earthquakes or floods. In either case, buildings or vehicles can release their hazardous materials inventories when structurally compromised or involved in traffic accidents. Pipelines can be exposed or ruptured from collapsed embankments, road washouts, bridge collapses, and fractures in roadways, and as nearly every neighborhood in urban King county includes a natural gas pipeline, this is a very possible risk. Examples of areas at risk for a secondary incident are Harbor Island, a western Washington facility with a large fuel storage area. Earthquake damage to Harbor Island could result in subsequent fuel spills that may impact the Duwamish River and Elliot Bay. These potential spills may occur from above ground storage, pipelines or fuel transfers from tankers. Events resulting from a spill would produce severe fire hazards and enormous environmental damages to fish, wildlife and commerce.

Additional potential causes of hazardous materials releases may include terrorist incidents and illegal drug labs or dumping. Illegal drug labs present a special concern due to the fact that each must be treated as a chemical hazard site and decontaminated before the property can be used again. Illegal drug labs can be set up in homes, apartments, vacant buildings, shacks in the forest or even in a van parked on the street.[37] Exposure of King County's sizable population to a hazardous materials release presents a complex problem to responders, since it is difficult to find a home, school, hospital or place of business in our modern society that isn't vulnerable to the possibility.

The chemical, physical and biological properties of hazardous materials pose a potential risk to life, health, the environment, and property when not properly contained. Hazardous materials may be explosive, flammable, combustible,

[37] Pierce County Department of Emergency Management Hazard Identification and Vulnerability Assessment, Technological Hazards Section: Hazardous Materials, http://www.co.pierce.wa.us/xml/abtus/ourorg/dem/EMDiv/HIVA/hazmat.pdf

corrosive, reactive, poisonous, biological or radioactive, as well as solid, liquid or gaseous. Hazardous materials incidents may be either generated from a fixed site or the result of a transportation-related accident or release.[38] Hazardous substances are subject to regulation by a variety of state and federal agencies through an assortment of labor, environmental and transportation laws.[39]

The types of materials that can cause a hazardous materials release are wide ranging in nature and may include chlorine, sodium hydroxide, sulfuric acid, radioactive isotopes, anhydrous ammonia, gasoline and other hydrocarbons, as well as medical/biological waste from hospitals or clinics. Hazardous materials subject to reporting under the Emergency Planning and Community Right-to-Know Act (EPCRA) or Title III of the Superfund Amendments and Reauthorization Act of 1986 (SARA) include these four groups:

Extremely Hazardous Substances: These are materials with acutely toxic properties that may do irreversible damage or cause death to people or harm the environment when released or used outside their intended use. Examples include: ammonia, chlorine, and sulfuric acid. Includes 366 US EPA listed chemicals.

Hazardous Substances: These are any materials posing a threat to human health and/or the environment, or any substance designated by the Environmental Protection Agency (EPA) to be reported if a designated quantity of the substance is spilled into the waters of the United States or is otherwise released into the environment.[40] Includes 720 chemicals listed by the US EPA.

Hazardous Chemicals: If present at a chemical facility in certain amounts, these substances require a Material Safety Data Sheet (MSDS) under the Occupational Safety and Health Administration (OSHA) Hazard Communication Standard. Such substances are capable of producing fires and explosions or adverse health effects such as cancer, burns, or dermatitis.[41]

Toxic Chemicals: Chemicals or chemical categories that appear on the list because of their chronic or long-term toxicity. Includes 325 chemicals. [42]

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[38] Pierce County Department of Emergency Management Hazard Identification and Vulnerability Assessment, Technological Hazards Section: Hazardous Materials, http://www.co.pierce.wa.us/xml/abtus/ourorg/dem/EMDiv/HIVA/hazmat.pdf
[39] Snohomish County Department of Emergency Management Hazard Identification and Vulnerability Assessment: Hazardous Materials Section, http://www.snodem.org/HIVA.pdf
[40] Snohomish County Department of Emergency Management Hazard Identification and Vulnerability Assessment: Hazardous Materials Section, http://www.snodem.org/HIVA.pdf
[41] Snohomish County Department of Emergency Management Hazard Identification and Vulnerability Assessment: Hazardous Materials Section, http://www.snodem.org/HIVA.pdf
[42] Pierce County Department of Emergency Management Hazard Identification and Vulnerability Assessment, Technological Hazards Section: Hazardous Materials, http://www.co.pierce.wa.us/xml/abtus/ourorg/dem/EMDiv/HIVA/hazmat.pdf

Other hazardous materials include hazardous wastes, by-products of society that can pose a substantial or potential hazard to human health or the environment when improperly managed, and possess at least one of four characteristics (ignitability, corrosivity, reactivity, or toxicity), or appear on special EPA lists.[43]

Hazardous Materials Impacts

The industrial and geographic characteristics of our region continue to place King County at risk for probably hazardous materials releases. Many factors determine the impact of a potential incident including quick and solid decision-making by emergency officials, location and type of release, evacuation and shelter-in-place needs, public health concerns, and relevant economic considerations. Additionally, while most incidents are generally brief, the resulting recovery and cleanup may take time to exact.

If evacuation is necessary due to a chemical emergency road closures and traffic jams may result. If a large-scale evacuation is deemed necessary, it can pose serious long term economic consequences to the involved population area.[44] A delay in the resumption of industry commerce may cause economic losses for both business owners and employees. In addition, an evacuation ordered on short-notice could cause serious problems for businesses requiring time to shut down specialized equipment.[45] There is also the monetary impact borne by responding public or private emergency response organizations. These agencies may be challenged by the expenses dictated by a hazardous materials release, and may need to wait an uncomfortable length of time for the responsible party to reimburse any outstanding costs, further straining the economic resources of the region.

A major incident involving significant injuries may severely tax regional medical services, as medical facilities aren't generally designed to handle mass amounts of victims on short notice. Consequently, in the event of a major incident, hospitals and other medical facilities must still be able to provide their customary level of service to all patients, regardless of whether they were incident victims or not.

If severe weather contributes to a flooding incident(s), as example along the Green River Valley and/or due to the Howard Hanson Dam situational awareness for 2009

[43] Snohomish County Department of Emergency Management Hazard Identification and Vulnerability Assessment: Hazardous Materials Section, http://www.co.snohomish.wa.us/documents/Departments/Emergency_Management/cemp_4-17-07_draft.pdf

[44] Snohomish County Department of Emergency Management Hazard Identification and Vulnerability Assessment: Hazardous Materials Section, http://www.co.snohomish.wa.us/documents/Departments/Emergency_Management/cemp_4-17-07_draft.pdf

[45] Snohomish County Department of Emergency Management Hazard Identification and Vulnerability Assessment: Hazardous Materials Section, http://www.co.snohomish.wa.us/documents/Departments/Emergency_Management/cemp_4-17-07_draft.pdf

and beyond, the hazard rankings in the introduction may be suddenly upgraded. Flooding impacts increases the risk of possible increased frequency of secondary hazards such as landslide, hazardous material spills or releases, fire hazards, and transportation system impacts.

History of Events

Hazardous materials emergencies have emerged as a public concern only within the past 30 years, as older records mixed hazardous materials emergencies with fire emergencies. As a result constructing a detailed history is difficult. This section highlights major incidents.[46]

A Washington State Department of Health study examined incidents occurring in 1992. According to the report there were 118 events in King County, about 10.2% involving transportation and 89.8% occurring at fixed facilities. Twenty-six incidents caused a total of 66 injuries, most commonly involving acids and volatile organic compounds. Additionally, 29 incidents resulted in the evacuation of nearly 1400 people. The report indicates that 44 incidents in King County occurred within one-quarter mile of residential areas, indicating some risk to people not directly involved with the released chemicals.[47]

A recent Washington State Hazard Identification and Vulnerability Analysis cited an average of 960 emergency spills occurring annually in King County. Significant events in King County detailed by the study include: the release of 2500 gallons of fuel from Olympic Pipeline at their Renton pumping station, the release of hydrofluoric and nitric acids from Boeing's Auburn plant, numerous drug lab events, metal finishing company fires at Boeing and Universal Manufacturing, a spill at UPS in Redmond, numerous releases of ammonia from cold storage facilities and the release of a small amount of chorine from a public water company. Response teams have narrowly averted some potentially large releases.

Hazardous materials may also be released during transport. For example, a 1994 King County study shows that the most common material transported along I-5 is gasoline. In addition, the most commonly released chemicals in transportation accidents included volatile organic compounds, acids, herbicides, and insecticides. Consequently, the Washington State Department of Transportation reported that almost 60,000 transportation incidents resulting in the accidental release of hazardous materials occurred between 1987 and 1989. Case in point of a typical problem posed by chemical transport involves a crash in 1975 where a gasoline tanker traveling north on the Alaska Way Viaduct lost control, bounced sideways, and crashed against the guardrail, where the tank ruptured. Gasoline flowed down the side of the Viaduct where it was ignited by flares set coincidentally by a railroad

[46] City of Seattle Emergency Management, Human-Caused Disasters: Hazardous Materials Resource Section, http://www.seattle.gov/emergency/hazards/hazardousMaterials.htm
[47] City of Seattle Emergency Management, Human-Caused Disasters: Hazardous Materials Resource Section, http://www.seattle.gov/emergency/hazards/hazardousMaterials.htm

crew. The resulting fire damaged several buildings, but there were no casualties.[48] As for railroad incidents however, King County has not had any significant events in recent years, although rail lines do run throughout downtown Seattle and populous areas of King County.

King County also has numerous abandoned hazardous waste sites that are being cleaned up under the Superfund program. In 2004, at least five sites in Kent and one very large site in South Seattle were identified. In 2009, twenty three sites are listed on the EPA website for small and large problems under the general category of Cleanup Sites, and three are Superfund sites, 2 located in Seattle, one in Renton. 48.5

Past Mitigation Efforts[49]

In 2004, there were sixteen hazardous materials response teams in King County. These were split evenly between public fire jurisdictions and the Boeing Company. It has changed somewhat for this 2009 update. Response capabilities are shared between 3 King County Zones (1, 3, and 5); with Boeing and the Port of Seattle having additional full response teams. Private response contractors working with the Environmental Protection Agency (EPA) and a unit of the Washington State Department of Ecology supplement the hazardous materials teams in King County.

An Area Contingency Plan was developed by the State Department of Ecology in cooperation with Federal, State and Local agencies. The purpose of the plan is "to provide orderly implementation of response actions to protect the people and natural resources of the states of Washington, Oregon, and Idaho from the impacts of oil or hazardous substances spills." The plan accounts for potential problems from vessels, offshore facilities, onshore facilities or other sources. The EPA has responsibility for all spills in inland waters. The United States Coast Guard has responsibility for all spills in coastal waters.

Other mitigation efforts include the Local Hazardous Waste Management Program, a regional consortium of local governments working together to protect public health and environmental quality by helping citizens, businesses and government reduce the threat posed by the use, storage, and disposal of hazardous materials. Prompted by citizen demand, this program was developed when Washington State directed local governments to create plans to ensure proper management of hazardous wastes produced by households, businesses, and other organizations. In 1991 local governments and agencies within King County established a partnership to manage these wastes regionally by developing the Local Hazardous

[48] City of Seattle Emergency Management, Human-Caused Disasters: Hazardous Materials Resource Section, http://www.seattle.gov/emergency/hazards/hazardousMaterials.htm
48.5 EPA Clean Up sites list for King County, WA
[49] Vulnerability Analysis prepared for the Local Emergency Planning Committee by Rich Tokarzewski, King County Office of Emergency Management

Waste Management Program.[50] This program offers information and services to help King County residents, businesses, and other groups reduce toxic and hazardous materials, safely use and store hazardous materials, and properly dispose of hazardous wastes.[51]

With 1.9 million (updated 2009) people living in King County and more than 60,000 businesses and other institutions operating therein, the amount of hazardous waste generated adds up.[51.5] When improperly used, stored or disposed of, these chemicals threaten human health and the environment. Moreover, exposure to some household products and business materials presents a risk to health and environmental quality even when used and disposed of properly. Program efforts focus on helping local residents, business owners and operators, and other institutions (such as schools, hospitals and government agencies): use fewer and/or less toxic materials (and generate less hazardous waste), properly use and store hazardous materials, and properly dispose of hazardous wastes.[52]

As demonstrated by the Local Hazardous Waste Management Program's efforts, public education is a key component to reducing the risks associated with a hazardous materials release. Educating the public on the fundamentals of shelter-in-place is also a key component. Citizens must know when, where, and how to shelter-in-place effectively, as this response mechanism is key to saving lives in a chemical emergency. Being aware and attentive of emergency officials and their public safety directives during a hazardous materials release will help ensure the protection of vulnerable populations and may lessen the economic impact of a release to the business and industrial community.

[50] Local Hazardous Waste Management Program in King County: Working Together to Reduce Hazardous Waste, http://www.govlink.org/hazwaste/about/
[51] Local Hazardous Waste Management Program in King County, http://www.govlink.org/hazwaste/
[51.5] *2009 Office of Financial Management Washington, April 2009*
[52] Local Hazardous Waste Management Program in King County: Working Together to Reduce Hazardous Waste, http://www.govlink.org/hazwaste/about/

Substantive additions made for 2009

Introduction

Transportation systems available in King County include air, rail, water and road. All of these systems and supporting transportation resources provide services on a national, regional and local basis and are critical to local, regional, national and international commerce. While highway traffic accidents are a daily occurrence, transportation accidents with impacts to local commerce or resulting in transportation diversions are fairly rare.

High Probability Low Impact	**High Probability Moderate Impact**	**High Probability High Impact**
Moderate Probability Low Impact	**Moderate Probability Moderate Impact**	**Moderate Probability High Impact**
Low Probability Low Impact	**Low Probability Moderate Impact**	**Low Probability High Impact**

Transportation Probability and Transportation Impacts

Hazard Identification

King County is a transportation hub in the northwest. Major highways, air transportation, railroad operations and a deep water marine port all exist in King county.

Highways: Privately owned vehicles and local bus services traveling on area freeways, highways and roads provide the primary means of transportation for individuals in King County. The principal north-south arterials are Interstate 5 and Interstate 405. Interstate 90, which connects Seattle with Spokane and points east, is the most heavily traveled east-west corridor. US Highway 2 crosses the Cascade Mountains in northeast King County at Steven's Pass. The two Floating Bridges over Lake Washington link Seattle to the eastern portion of the county as well as eastern Washington, Idaho, Montana and other states.

Air Transportation: The largest airport in King County, for both passenger and cargo traffic, is the Seattle-Tacoma International Airport, where domestic and international service is provided by several major airlines. Sea-Tac is the largest airport in

Washington and was ranked 17th in the United States for passenger carriage in 2008.[53] (Updated 2009)

Sea-Tac generates substantial economic impacts to the region, as shown by the total combined direct output of on-airport tenants and general aviation and air carrier visitors, which was approximately $13.1 billion. Additionally, these expenditures were responsible for approximately 89,902 jobs, generating $2.15 billion in wages. Sea-Tac also provides numerous secondary impacts to the King County area through visiting passengers and airport-dependant firms, accounting for 35,584 jobs and posting wages of $1.9 billion. The total employment impact of Sea-Tac stands at approximately 138,370 earning $4.5 billion, while the sum total impact of economic activity was $17.6 billion.[54]

Rail Transportation: Rail Carriers in this area include Burlington Northern – Santa Fe and the Union Pacific for freight traffic, and Amtrak for passenger travel. North-South railways travel along the coastline though much of King County. East-West rail traffic primarily uses Steven's Pass, traveling a 7-mile tunnel through the Cascade Mountains. Sounder commuter rail service initially provided one-way service during peak hours between Tacoma and Seattle on weekdays, while service recently expanded to operate along the entire 82-mile track between Everett and Lakewood.[55] (Updated 2009)

Marine Transportation: As with other modes of transportation, there are both passengers and cargo transported in King County. The Washington State Ferry System provides the primary means of marine passenger transport in our region with four ferry terminals located in the County jurisdiction. In 1995, 1256 different ships made 3,619 calls to Puget Sound ports either through the Straits of Juan de Fuca or the Straits of Georgia.[56]

Washington State Ferries is the largest ferry transit system in the United States and one of the busiest, carrying over 24 million riders in 2008, and is the largest transit system in Washington State, second only to King County Metro. Commuters make up about 50% of the annual ridership, as exemplified by the busiest commuter route, Bainbridge to Seattle, where 18,000 people are carried in an average day.[57] (Updated 2009).

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[53] Washington State Department of Transportation Aviation Division Report on the Economic Impacts of Seattle-Tacoma International Airport, http://www.wsdot.wa.gov/NR/rdonlyres/2829F10B-E191-4A7A-ABB0-E51D728E533E/0/NWR_SeaTac.pdf

[54] Port of Seattle- SeaTac http://www.portseattle.org/downloads/seatac/2007activity.pdf , http://www.portseattle.org/downloads/business/EconomicImpact_20091.pdf

[55] Pierce County Department of Emergency Management, Hazard Identification and Vulnerability Assessment, Technological Hazards: Transportation Accidents, http://www.co.pierce.wa.us/pc/abtus/ourorg/dem/techaz.htm

[56] Washington State Office of Marine Safety, Vessel Entries and Transits for Washington Waters, 1995, p B2.

[57] Washington State Ferries: An Introduction to the Largest Ferry System in the Nation, http://www.wsdot.wa.gov/ferries/pdf/WSFLargest.pdf

Additional water transport systems exist with the Port of Seattle and numerous private marine facilities located on Puget Sound, Lake Union and Lake Washington, which provide services and docking facilities for marine cargo and tanker traffic.

Transportation Impacts

The Puget Sound region is vulnerable to all types of transportation emergencies. Growth in this region will continue to increase the risk of transportation accidents.

Highways: King County is likely to experience an increase of accidents along our highways as congestion increases. Many accidents involve rain, high speeds, and heavy traffic. These conditions are certainly not unique, as rain and fog are common, especially during the winter months, while heavy traffic and high speeds are common throughout the year. The bridges in King County play an important role in commerce and in the daily commute. Thanksgiving Day weekend in 1990, a span of the I-90 floating bridge over Lake Washington sank. While the span was replaced and a second bridge built, traffic patterns were disrupted for two years.

Air Transportation: The Puget Sound region is vulnerable to two types of major air transportation accidents. One is a crash involving a large passenger aircraft, while the other is an airplane crash causing casualties on the ground. Despite the large number of planes flying over heavily populated areas, the number of crashes killing or injuring non-passengers is quite small. In general, crashes are most likely to occur within five miles of an airport, typically along flight paths. The area within a five mile radius of airports in the Puget Sound region are heavily populated and therefore could result in a mass casualty event if a plane crashed in these areas, even if the plane itself was not a passenger aircraft. Weather is a significant factor in these air transportation accidents. Down bursts, thunderstorms, and ice are the primary weather-related events that increase risk.

Sea-Tac Airport is becoming as congested as some of the nation's major airports including Chicago's O'Hare and New York City's Kennedy airports. Currently, King County International Airport averages 400,000 flights per year while Sea-Tac is reaching its design capacity with 347,046 (updated 2009) flights per year. [58] The proximity of King County International Airport's flight path also increases the risk. The flight paths for these two airports overlap, increasing the risk of mid-air collisions. With the completion of a third runway, congestion will be reduced, but the total volume of flights over Seattle will probably increase, offsetting some of the benefits of the reduced congestion.

[58] City of Seattle Emergency Management, Human Caused Disasters: Aircraft Accidents Resource Section July 2009 update, http://www.seattle.gov/emergency/library/Haz%20Mit%20Plan%20Feb%2004.pdf

Rail Transportation: An accident involving an Amtrak train traveling through Washington State could result in a mass casualty incident. However, the greatest risk associated with freight trains is a spill of hazardous materials.[59] Nevertheless, with the development of Sound Transit, King County's railway vulnerability will increase, as new hazards may present themselves with the continued growth of this light rail service.

Marine Transportation: In addition to the Puget Sound itself, the region contains many smaller bodies of water. These areas are vulnerable to shipping and boating accidents, as well as those involving ferries. Ferry accidents could result in a mass casualty incident that may be difficult to address, though the United States Coast Guard has the primary responsibility for safety and rescue on the open waterways. Major emergencies associated with freight vessels though, are more likely to result from spills or collisions with passenger vessels.

History of Events

Highway Accidents: King County has slowly increased in traffic related deaths between 1998 and 2007, by about 2.5%.[60] Over the course of 2007 170 traffic deaths were reported. Past history also shows the potential for major incidents, like a 42 car pileup that occurred in 1996, closing southbound Interstate 5 for four hours, and was responsible for 23 injuries and one death.

Marine Accidents: It is fortunate that the Puget Sound region has not experienced a major incident involving a Washington State Ferry, but with an examination of the history of near misses or hard landings into docks, one can see that potential for a fatal accident does exist. For example, two incidents in 1994 involved a ferry running aground off Orcas Island, as well as a ferry colliding with a pleasure craft while attempting to dock.[61] Additionally, in the case of freight vessels, a Canadian Study that examined past collisions, accidents, and groundings in the Straits of Juan de Fuca, found that 56% involved bulk carriers, 12% involved container vessels, 12% involved passenger vessels and 18% involved tankers. Tankers are currently the most heavily regulated, as the Exxon Valdez oil spill in Alaska caused Washington State to pass strict regulations on their usage.

Air Accidents: The last accident occurred on September 29, 2005 when a medical helicopter crashed into the Puget Sound near Edmonds, killing three. Though infrequent, accidents in other parts of the country allow us to examine the potential vulnerabilities we face in this area.[58] In 1995 there were 175 deaths associated

[59] Transportation accidents involving hazardous materials releases and spills are discussed in a separate HIVA section.
[60] Washington Traffic Safety Commission: Fatalities by County, http://www.wtsc.wa.gov/research/data/data09/county_state_datatables98_07.pdf
[61] Taken from 1997 King County Hazard Identification and Vulnerability Assessment. http://www.kingcounty.gov/healthservices/health/news/2008/08123102.aspx

with large scheduled airline traffic and 732 deaths associated with general aviation flights. King County is at risk for these threats, as the region experiences extensive air traffic of both these types. SeaTac airport handles most of the scheduled airline traffic while King County International Airport/Boeing Field handles most of the general aviation traffic. A relatively minor commercial air traffic accident occurred when a Dash 8 commuter plane lost control after landing at SeaTac International Airport. It crashed into the terminal building causing some damage but no deaths or service disruptions.

Rail Accidents: The Puget Sound region has not experienced a major rail accident in recent history, however recent examples point to the potential for this hazard to occur in King County. For example, a massive landslide in nearby Snohomish County pushed five freight cars into Puget Sound, knocking out 100 yards of track. Railroad-related fatalities, on the other hand, are generally the result of people walking on or near railroad tracks. A 1994 statistic gathered that almost 75% of railroad-related deaths were attributed to such a situation.[62]

Past Mitigation Efforts

The source and location of transportation accidents can vary widely but the response is typically the same. Response is focused on determining the presence or absence of hazardous materials and then assisting the injured. Local emergency managers should work with transportation planners to mitigate current risks associated with major transportation corridors. Additionally these agencies should work together when planning new infrastructure such as the Regional Transit Authority or a third runway at SeaTac Airport to minimize associated risks.

For any type of transportation accident, mitigation involves first and foremost, the following of safety guidelines as well as using caution in unusual conditions or situations. Inspections required on a regular basis on carriers, as well as infrastructure like highways, airports, railroad, or marine systems must be carried through as required by the regulations in place in order to prevent transportation incidents. In addition, as new technology comes into being or new information is gathered as to the cause of transportation accidents, regulations on safety and maintenance need to be updated. [63]

Additionally, local media outlets, as well as King County Department of Transportation take care to keep the public updated of transportation-related emergencies and resulting highway, airport, rail, or ferry delays and closures. The Regional Public Information Network (RPIN) also provides the public with a central source for breaking news by providing links to information being released by a

[62] Taken from 1997 King County Hazard Identification and Vulnerability Assessment.
[63] Pierce County Department of Emergency Management, Hazard Identification and Vulnerability Assessment, Technological Hazards: Transportation Accidents, http://www.co.pierce.wa.us/pc/abtus/ourorg/dem/techaz.htm

variety of agencies and organizations in central Puget Sound, including those incidents involving transportation accidents.[64] Citizens can subscribe to RPIN to stay abreast of breaking transportation news and other regional alerts.

[64] Regional Public Information Network (RPIN), http://www.govlink.org/rpin/

No substantive changes made in 2009

Introduction

Tsunami (soo-NAH-mee): a Japanese word that means harbor wave; a sea wave of local or distant origin that results from large-scale seafloor displacements associated with large earthquakes, major submarine slides, or exploding volcanic islands. [65]

Tsunamis, often incorrectly described as tidal waves, are sea waves usually caused by displacement of the ocean floor. Typically generated by seismic or volcanic activity or by underwater landslides, a tsunami consists of a series of high-energy waves that radiate outward like pond ripples from the area in which the generating event occurred. The arrival of tsunami waves is usually typified by a sudden and unexpected recession of water; the first wave will be followed by additional waves a few minutes or even a few hours later. Wave size typically increases over time, and coastal flooding may often precede the largest waves.

Seiche (saysh): a series of standing waves (sloshing action) of an enclosed body or partially enclosed body of water caused by earthquake shaking. Seiche action can affect harbors, bays, lakes, rivers, and canals. [66]

Tsunami and Seiche events occur only very infrequently in Puget Sound.

High Probability Low Impact	**High Probability Moderate Impact**	**High Probability High Impact**
Moderate Probability Low Impact	**Moderate Probability Moderate Impact**	**Moderate Probability High Impact**
Low Probability Low Impact	**Low Probability Moderate Impact**	**Low Probability High Impact**

Tsunami / Seiche Probability and Tsunami / Seiche Impacts

Hazard Identification

Normally caused by earthquake activity, tsunamis and seiches can affect harbors, bays, lakes, rivers, and canals. In the majority of instances, earthquake-induced

[65] Skagit County Natural Hazards Identification Plan, http://www.skagitcounty.net/emergencymanagement/documents/2008hazplandraft/section%20ii%20final%20documents/9%20hiva%20skagit%20tsunami%20and%20seichei.pdf
[66] Skagit County Natural Hazards Identification Plan, http://www.skagitcounty.net/emergencymanagement/documents/2008hazplandraft/section%20ii%20final%20documents/9%20hiva%20skagit%20tsunami%20and%20seichei.pdf

events do not occur close to the epicenter of an earthquake, but hundreds of miles away. Earthquake shock waves close to the epicenter consist of high frequency vibrations, while those at much greater distances are of lower frequency. It is the low frequency vibrations that move bodies of water. The biggest tsunamis and seiches develop when the period of ground movement matches the frequency of oscillation in the body of water.[67]

Not all earthquakes produce tsunamis. To generate a tsunami, an earthquake must occur underneath or near the ocean, be very large (approximately Richter magnitude 7 or greater), and create vertical movement of the sea floor. All oceanic regions of the world can experience tsunamis, but in the Pacific Ocean there is a much more frequent occurrence of large, destructive tsunamis because of the many large earthquakes along the boundaries of the Pacific Ocean's "Ring of Fire." [68]

Tsunamis can be intensely powerful, as large Pacific Ocean tsunamis typically have wave crest to wave crest distances of 60 miles and can travel about 600 miles per hour in the open ocean, navigating the entire 12,000 to 14,000 miles of the Pacific Ocean in just 24 hours. In deep ocean waters, the length from wave crest to wave crest may be a hundred miles or more but only reaches a wave height of less than a few feet. As a result, tsunamis cannot be felt aboard ships nor can they be seen from the air in the open ocean. [69]

Tsunamis and seiches can be generated by a number of sources:

1. Distant earthquakes along the Pacific Rim.

2. Local earthquakes, such as those generated by local surface faults, those originating in the Benioff zone, or those that occur in the Cascadia Subduction Zone off the coast.

3. Large landslides into bodies of water, such as Puget Sound or area lakes.

4. Submarine landslides in bodies of water like Puget Sound.[70]

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[67] Snohomish County Department of Emergency Management Hazard Identification and Vulnerability Assessment, http://www.co.snohomish.wa.us/documents/Departments/Emergency_Management/cemp_4-17-07_draft.pdf

[68] Snohomish County Department of Emergency Management Hazard Identification and Vulnerability Assessment, http://www.co.snohomish.wa.us/documents/Departments/Emergency_Management/cemp_4-17-07_draft.pdf

[69] Skagit County Natural Hazards Identification Plan, http://www.skagitcounty.net/emergencymanagement/documents/2008hazplandraft/section%20ii%20final%20documents/9%20hiva%20skagit%20tsunami%20and%20seichei.pdf

[70] Washington State Hazard Mitigation Plan, Region 6, http://www.emd.wa.gov/plans/documents/Tab_4_Planning_Process.pdf

Either a large subduction zone quake off the coast or along the Seattle fault could produce a tsunami, however, while a tsunami generated by a distant or Cascadia subduction earthquake could result in much damage to the coast, it wouldn't create as great of an impact in King County. For in the case of a subduction zone quake, a tsunami would travel from the coast through the Straight of Juan de Fuca into Puget Sound, and then south to Seattle. Because of the shielding effects of the Olympic Peninsula and the islands in Puget Sound, the tsunami expected from a magnitude 8.5 quake would be less then 2 feet high when it arrived at Seattle's shores, having lost much of its' velocity.[71] As a result, primary concerns lie with a tsunami or seiche generated by a land movement originating on the Seattle fault, which runs off the northern end of West Seattle through Elliott Bay towards the Kingdome (which was demolished on October 6, 2006 and replaced by the Safeco Field area) and across toward Bellevue. [72]

The National Oceanic and Atmospheric Administration (NOAA)'s Center for Tsunami Inundation Mapping Efforts developed a tsunami inundation model for Seattle's Elliott Bay using a magnitude 7.3 Seattle Fault earthquake as an initiating event (this model simulates the earthquake event 1,000 years ago, considered by NOAA to be the credible worst-case scenario.) The area modeled includes communities within one kilometer of the Puget Sound coast, such as portions of Seattle, Riverton-Boulevard Park and White Center, and projects a potential at-risk population of 11,056.[73]

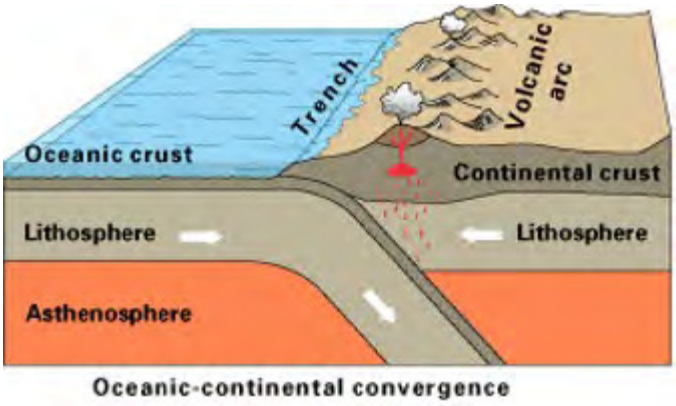
For example, in addition to Lake Washington, Lakes Sammamish and Union have many watercrafts, houseboats, docks, piers, houses and buildings located on or close to their waterfronts. Our area floating bridges may also be at risk for seiche damage. Additional vulnerabilities to seiche in King County include water storage tanks and containers of liquid hazardous materials, which could be affected by the rhythmic motion of a "sloshing" seiche.

Note: At the time of this 2009 Update, the Seattle Hazard Mitigation Plan is pending FEMA approval and is not available for current citation references.

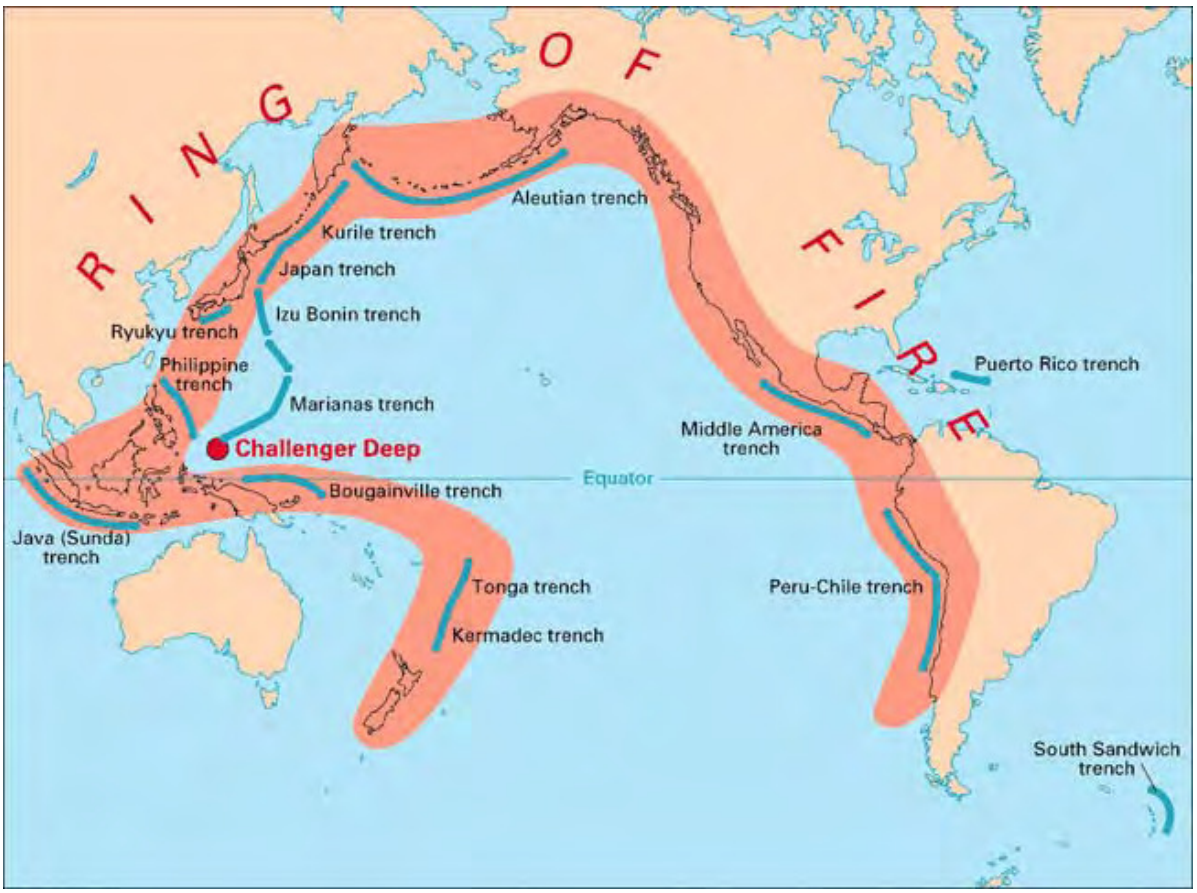
[71] City of Seattle Emergency Management Natural Hazards, Tsunami and Seiche Section, http://www.seattle.gov/emergency/hazards/tsunamiseiches.htm

[72] City of Seattle Emergency Management Natural Hazards, Tsunami and Seiche Section, http://www.seattle.gov/emergency/hazards/tsunamiseiches.htm

[73] City of Seattle Emergency Management Natural Hazards, Tsunami and Seiche Section, http://www.seattle.gov/emergency/hazards/tsunamiseiches.htm



Source: Peninsula Emergency Preparedness Committee, Pacific Northwest Tsunamis Resource Section, http://www.pep-c.org/pacificnorthwesttsunamis/



Source: National Geophysical Data Center (NGDC) 2007, http://celebrating200years.noaa.gov/magazine/dart_buoys/ring_of_fire.html

Hazard Impact

Several factors could influence the size, shape, volume, and potential destructiveness of a tsunami generated by the Seattle Fault. First, since Elliott Bay and Puget Sound are shallow, there is less water to displace; therefore, a resulting tsunami would be slower and have less volume than those generated in the deep ocean. Second, Puget Sound's steeply sloping seabed tends to increase the chance that a tsunami will break on the shore, thus potentially enhancing a tsunami's destructiveness. Finally, the shape of Elliott Bay could increase damage by funneling waves together, increasing wave height. The net result is unclear, as the depth versus shape relationship of Elliot Bay is relatively unknown.[74]

Estimated recurrence rate of an earthquake on the Seattle fault of the size necessary to generate a tsunami or seiche is estimated at once every 1,100 years. Great earthquakes in the North Pacific or along the Pacific coast of South America that generate tsunamis that sweep through the entire Pacific basin occur at a rate of about six every 100 years.[75]

With regards to seiche threats, both Puget Sound and Lake Washington could experience a seiche as they did in 1891, 1949 and 1964. In those years, there was not as much development near the waterfront as there is now. As a result, since the tsunami and seiche threats were not recognized until recently, most of the structures located near the water were probably not engineered to withstand them.[76]

The potential impact to bridges is expected to be minimal, since the Washington State Department of Transportation anticipates that storm-generated wave forces would exceed the force created by a small to moderate-sized tsunami. As to the possibility of earthquake-induced liquefaction impacting bridge support, bridge design assumes seismic effects to govern.[77]

Additional impacts from a tsunami include floating debris with the potential to batter and damage inland structures. The sheer impact of the waves could even cause breakwaters and piers to collapse. Ships moored in harbors would also be at risk, as they could be swamped, sunk or left battered and stranded high on the shore. In addition, railroad yards and oil tanks situated near the waterfront would also be particularly vulnerable, as resulting oil fires are often spread by waves.

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[74] City of Seattle Emergency Management Natural Hazards, Tsunami and Seiche Section, http://www.seattle.gov/emergency/hazards/tsunamiseiches.htm
[75] Washington State Hazard Mitigation Plan, Region 6, http://www.emd.wa.gov/plans/documents/Tab_4_Planning_Process.pdf
[76] City of Seattle Emergency Management Natural Hazards, Tsunami and Seiche Section, http://www.seattle.gov/emergency/hazards/tsunamiseiches.htm
[77] City of Seattle Emergency Management Natural Hazards, Tsunami and Seiche Section, http://www.seattle.gov/emergency/hazards/tsunamiseiches.htm

Moreover, port facilities, fishing fleets, and public utilities are frequently the backbone of the economy of the affected areas, and these are the very resources that generally receive the most severe damage. Until debris can be cleared, wharves and piers rebuilt, utilities restored, and the fishing fleets reconstituted, communities may find themselves without fuel, food, and employment. Wherever water transport is a vital means of supply, disruption of coastal systems caused by tsunamis can have far reaching economic effects. For example, Port of Seattle facilities and the Burlington Northern Railway tracks are likely to suffer damage because of their proximity to the shore.[78]

A seiche could affect a larger area because of King County's extensive shoreline, and could also affect the floating bridges across Lake Washington. While, the bridges have withstood waves up to eight feet, waves from a seiche could be much larger. A seiche's rapid onset could also hamper the ability of motorists to exit the bridge before it began.[79] Additionally, the "sloshing" effect of a seiche could cause damage to moored boats, piers and facilities close to the water. Secondary problems, including landslides and floods, are related to accelerated water movements and elevated water levels. Many landslide prone bluff areas are in residential settings, so risk could be quite high in the event of a secondary seiche threat.

History of Events

On average, the west coast of the United States experiences a damaging tsunami every 18 years. Geologic evidence shows that the Cascadia Subduction Zone has generated great earthquakes in the past, the most recent about 300 years ago. Any large earthquake has the capability to generate a tsunami or severe seiche action. Recent studies regarding the potential for a great Subduction zone earthquake off the Washington, Oregon, and Northern California coastlines indicate that local tsunami waves may reach nearby coastal communities within minutes of the earthquake thereby giving little or no time to issue warnings.[80]

Local studies of the Seattle Fault indicate a potential for tsunamis. Scientists interpret the evidence of irregular sand sheets in the Northern Puget Sound area found at the West Point Sewer Treatment Plant, Alki, and Restoration Point on Bainbridge as the result of a tsunami generated by an earthquake on the Seattle fault about 1,000 years ago.[81]

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[78] City of Seattle Emergency Management Natural Hazards, Tsunami and Seiche Section, http://www.seattle.gov/emergency/hazards/tsunamiseiches.htm
[79] City of Seattle Emergency Management Natural Hazards, Tsunami and Seiche Section, http://www.seattle.gov/emergency/hazards/tsunamiseiches.htm
[80] Skagit County Natural Hazards Identification Plan, http://www.skagitcounty.net/emergencymanagement/documents/2008hazplandraft/section%20ii%20final%20documents/9%20hiva%20skagit%20tsunami%20and%20seichei.pdf
[81] City of Seattle Emergency Management Natural Hazards, Tsunami and Seiche Section, http://www.seattle.gov/emergency/hazards/tsunamiseiches.htm

Similar evidence in Lake Washington sediments suggests a recurrence interval of 300 to 400 years. Several areas of the Seattle Fault show evidence of episodic fault rupture of about 6 feet that could produce a tsunami. Continued studies of Seattle Fault traces suggest that the fault may have ruptured in different segments and at different times.[82]

Table 5-15: History of Tsunami and Seiche in King County

Year	Conditions
A.D. 900-930	A magnitude 7 or greater earthquake on the Seattle fault created uplift on the floor of Puget Sound. The uplift generated a tsunami that deposited a sand sheet at West Point and the Duwamish Delta in Seattle. Computer simulations showed the tsunami reached heights of 10 feet or more on the Seattle waterfront.
1891	Water in Lake Washington and Puget Sound surged onto beaches two feet above the high water mark from two earthquake shocks and submarine landslides. This earthquake near Port Angeles also caused an eight-foot seiche in Lake Washington.
1949	Both Lake Union and Lake Washington experienced seiches during the 1949 earthquake (M7.1), but they did no damage.
1964	The tsunami generated by the magnitude 9.2 Alaska earthquake raised the water level 0.1 feet in Elliott Bay, Seattle. Seiches damaged houseboats, buckled moorings, and broke water and sewer lines in Lake Union. However, the tsunami's effect was negligible in Seattle because the complicated shoreline in Puget Sound acted as a baffle for incoming ocean waves.
1965	Due to a local earthquake event (M6.5), sloshing action was observed in area lakes.
2002	Seiches damaged houseboats, buckled moorings, and broke water and sewer lines in Lake Union following an Alaskan earthquake (Denali, M7.9).

Sources: Washington State Hazard Mitigation Plan, Region 6, http://www.emd.wa.gov/plans/documents/Tab_4_Planning_Process.pdf; City of Seattle Emergency Management Natural Hazards, Tsunami and Seiche Section, http://www.seattle.gov/emergency/hazards/tsunamiseiches.htm

[82] City of Seattle Emergency Management Natural Hazards, Tsunami and Seiche Section, http://www.seattle.gov/emergency/hazards/tsunamiseiches.htm

Past Mitigation Efforts

Since it is known that the speed of tsunamis varies with water depth, the prediction of tsunami arrival times at coastal locations is possible once the epicenter has been determined. But it is not yet possible to predict the wave height at a specific coastal location. Another indeterminable feature of a tsunami is how many successive waves there will be in the series, although there is rarely only one. However, efforts and programs exist to help mitigate the damage wrought by tsunamis and seiches, especially by providing warnings to vulnerable areas.

The Tsunami Warning System (TWS) in the Pacific, comprised of 26 participating international member states, monitors seismological and tidal stations throughout the Pacific Basin. The System evaluates potentially tsunami-generating earthquakes and disseminates tsunami warning information. The Pacific Tsunami Warning Center (PTWC) is the operational center of the Pacific TWS. [83]

The PTWC was instituted in 1948 following the extensive damage and loss of life in Hawaii caused by a tsunami generated by the great Aleutian Islands earthquake of 1946. [84] The PTWC is comprised of member nations and states that seek to coordinate tsunami detection and warning efforts within the area. The PTWC is responsible for providing warnings to international authorities, Hawaii, and U.S. territories within the Pacific basin.

Another mitigation program is the West Coast/Alaska Tsunami Warning Center (WC/ATWC), responsible for tsunami warnings for California, Oregon, Washington, British Columbia, and Alaska. [85] The devastation associated with the 1964 Alaskan earthquake and tsunami, led to the institution of the WC/ATWC in 1967. It serves as the regional warning center for Alaska, British Columbia, Washington, Oregon and California. This system is intended to detect, locate and calculate the magnitude of earthquakes in the region as quickly as possible and issue warnings to communities close to the epicenter.

The PTWC and WC/ATWC may issue the following bulletins:

WARNING: A tsunami was or may have been generated, which could cause damage; therefore, people in the warned area are strongly advised to evacuate.

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[83] Snohomish County Department of Emergency Management Hazard Identification and Vulnerability Assessment, http://www.co.snohomish.wa.us/documents/Departments/Emergency_Management/cemp_4-17-07_draft.pdf

[84] Snohomish County Department of Emergency Management Hazard Identification and Vulnerability Assessment, http://www.co.snohomish.wa.us/documents/Departments/Emergency_Management/cemp_4-17-07_draft.pdf

[85] Peninsula Emergency Preparedness Committee, Tsunami Warning Resource Section, http://www.pep-c.org/pacificnorthwesttsunamis/

This notification also gives time of arrival estimations to the vulnerable areas in question.

WATCH: A tsunami was or may have been generated, but is at least two hours travel time to the area in watch status. Local officials should prepare for possible evacuation if their area is upgraded to a warning.

ADVISORY: An earthquake has occurred in the Pacific basin, which might generate a tsunami. WC/ATWC and PTWC will issue hourly bulletins advising of the situation.

INFORMATION: A message with information about an earthquake that is not expected to generate a tsunami. Usually only one bulletin is issued.[86]

Recent revelations about the potential for a great subduction zone earthquake off the Washington, Oregon, and Northern California coastlines have led to several studies about the effect of a local tsunami generated in this source area. FEMA estimates that a Cascadia Subduction Zone earthquake-generated tsunami could cost $25-125 billion in damages to the region. If one assumes that the tsunami would cause 5% of these losses, then the tsunami losses would total between $1.25 and 6.25 billion. More significantly, the population directly at risk from a Cascadia tsunami is significant. About 300,000 people live or work in coastal regions that could be affected and at least as many tourists travel through these areas each year. Some tourism and financial corporations already plan for and educate employees about tsunamis. Others are interested but do not know where to begin and are unaware of the potential losses in terms of lives, operations, and clients.[87]

Early warning, coupled with education of the affected populations, proper zoning, and suitable structural design can aid in reducing the disastrous effect of this natural hazard. If warning is received early enough (2 to 5 hours), which is possible for tsunamis generated at a distance, hasty preventive action can be taken: people can be evacuated, ships can clear harbors or seek safer anchorage, planes and rolling stock can be moved, buildings can be closed, shuttered, and sandbagged. For tsunamis generated by local events, however, the time from initiation of a tsunami to its arrival at shore can be as little as a couple of minutes. Residents in areas susceptible to tsunamis should be made aware of the need to seek high ground if they feel strong ground shaking. Coastal communities should identify evacuation routes even if they do not have good information about potential inundation areas.

[86] American Red Cross Tsunami Resource Section, http://www2.redcross.org/news/in/tsunamis/faq.asp

[87] Snohomish County Department of Emergency Management Hazard Identification and Vulnerability Assessment, http://www.co.snohomish.wa.us/documents/Departments/Emergency_Management/cemp_4-17-07_draft.pdf

Seiches that occur in King County also have the potential to cause property damage and casualties. Although much work has been done on disaster preparedness for the public, local governments, emergency planners and the citizenry need to recognize the dangers and effects of seiches as an important component of the earthquake/tsunami hazard.

Because King County is most vulnerable to tsunamis and seiches produced by a local quake, comprehensive educational programs that keep the public informed of the dangers and steps to be taken for personal protection are especially important. In these instances, there may not be enough time between the triggering event and the arrival of the first wave for effective warning.

Cyberterrorism

No substantive changes made in 2009

Introduction

Cyberterrorism presents a hazardous threat to our increasingly digital world. The possibility of a major cyberterrorism attack in the United States would threaten infrastructure, financial systems, and everyday computing across the nation and here in Western Washington. Even more limited cyber infringement actions can disrupt the lifestyle of Central Puget Region residents and the daily activities of public, private, and nonprofit sector business and organizations, leading to potentially costly outcomes.

Far from the generally understood Internet irritations like "spam" (unwanted email) or "phishing" (email attempts to get the user to divulge private information like account numbers), cyberterrorism is much more sinister enterprise – a convergence of terrorism and cyberspace. By definition, it is generally understood to mean unlawful attacks and threats of attack against computers, networks, and the information stored therein when done to intimidate or coerce a government or its people in furtherance of political or social objectives. [1] Examples include attacks that lead to death or bodily injury, explosions, plane crashes, water contamination, or severe economic loss.[2]

Cyberterror can take a variety of different forms including:

Internet worms or viruses: these internet "viruses" or "worms" can be used to shut down programs, or even entire systems by hijacking email lists and address books. Worms or viruses may also be used to target communication devices like cellular phones or personal data assistants.

Phlooding: this new exploit targets businesses' central authentication servers with the goal of overloading them and causing a denial−of−service attack. These simultaneous but geographically distributed attacks have targeted but are not restricted to wireless access points with login requests using multiple password combinations in what are known as dictionary attacks. The multiple requests create a flood of authentication requests to the company's authentication server, which could slow down logins and potentially interfere with broader network operations, since many different users and applications often validate themselves against the same identity management system. Phlooding could effectively block broadband VPN or firewall connections making it temporarily impossible for employees to access their corporate network.[3]

System Threats: threats to various systems, new and antiquated, that power our everyday operations. An example of a new threat would be one to the security of

Voice-Over Internet Protocol (VoIP) processes, whose similarity to traditional data systems may become attractive to attackers, impacting the public's ability to utilize emergency services, or limit the ability of public safety organizations to act quickly in an emergency.[4]

Force Multiplier effects: Acts of cyberterror may also be used to multiply the impact of a physical attack when executed in concert. For example, terrorists might try to block emergency communications or cut off electricity or water in the wake of a conventional bombing or a biological, chemical, or radiation attack would impact the potential response capability for the initial attack. Many experts say that this kind of coordinated attack might be the most effective use of cyberterrorism.[5] Also, with much of the world becoming more web-savvy, terrorists are doing the same – experts are warning against terrorists researching hacker tactics in efforts to use the technology for their aims.[6]

High Probability Low Impact	**High Probability Moderate Impact**	**High Probability High Impact**
Moderate Probability Low Impact	**Moderate Probability Moderate Impact**	**Moderate Probability High Impact**
Low Probability Low Impact	**Low Probability Moderate Impact**	**Low Probability High Impact**

Cyberterrorism Probability and Cyberterrorism Impact

To understand the potential threat of cyberterrorism, two factors must be considered: first, whether there are targets that are vulnerable to attack that could lead to violence or severe harm, and second, whether there are actors with the capability and motivation to carry them out.[7]

Although many of the weaknesses in computerized systems can be corrected, it is effectively impossible to eliminate all of them. Even if the technology itself offers good security, it is frequently configured or used in ways that make it open to attack. In addition, there is always the possibility of insiders, acting alone or in concert with other terrorists, misusing their access capabilities.[8] With American society increasingly interconnected and ever more dependent on information technology, terrorism experts worry that cyberterrorist attacks could cause as much devastation as more familiar forms of terrorism.[9]

Cyberterrorism could involve destroying the actual machinery of the information infrastructure; remotely disrupting the information technology underlying the Internet, government computer networks, or critical civilian systems such as financial networks or mass media. Cyberterror could also include using computer networks to take over machines that control traffic lights, power plants, or dams in order to wreak havoc on unsuspecting populations.[10]

Hazard Identification

While some people use the term “cyberterrorism” to refer to any major computer-based attack on the U.S. government or economy, many terrorism experts would not consider cyberattacks by glory-seeking individuals, organizations with criminal motives, or hostile governments engaging in information warfare to be cyberterrorism. Like other terrorist acts, cyberterror attacks are typically premeditated, politically motivated, perpetrated by small groups rather than governments, and designed to call attention to a cause, spread fear, or otherwise influence the public and decision-makers. Terrorists try to leverage limited resources to instill fear and shape public opinion, and dramatic attacks on computer networks could provide a means to do this with only small teams and minimal funds. “Virtual” attacks over the Internet or other networks allow attackers to be far away, making borders, X-ray machines, and other physical barriers irrelevant.[11]

Acts of cyberterror can be used to disrupt our society and exploit our increasing reliance on computers and telecommunication networks, threatening the electronic infrastructure that supports computer networks tasked to regulate the flow of power, water, financial services, medical care, telecommunication networks, and transportation systems. The public and private sectors' unprecedented dependence on information and communications systems, computers, and networks, must recognize that networks are vulnerable to attack from any source. Also, the ability to distinguish a singular hacker-type incident from a cyberterrorist attack may not be readily evident, as tools for conducting cyberterrorism are widely available, broadly advertised, and easily used. Potential attackers only require access to a computer and a telecommunications network. [12]

As assessed by the Center for the Study of Terrorism and Irregular Warfare at the Naval Postgraduate School in Monterey, California, cyberterror capability can be described as:

Simple-Unstructured: The capability to conduct basic hacks against individual systems using tools created by someone else. The organization possesses little target analysis, command and control, or learning capability.[13]

Advanced-Structured: The capability to conduct more sophisticated attacks against multiple systems or networks and possibly, to modify or create basic hacking tools. The organization possesses an elementary target analysis, command and control, and learning capability. [14]

Complex-Coordinated: The capability for coordinated attacks capable of causing mass-disruption against integrated, heterogeneous defenses (including cryptography). Ability to create sophisticated hacking tools. Highly capable target analysis, command and control, and organization learning capability. [15]

Hazard Impacts

Cyber-attacks against computer systems could potentially shut down radio, telephone, and computer networks used to control and manage city or regional services, potentially resulting in loss of those services or the inability to properly dispatch public safety and other personnel to the scenes of crimes or physical terrorist attacks.[16]

Attacks on physical components of our information infrastructure could resemble other conventional attacks: for example, a bomb could be used to destroy a government computer bank, key components of web-based infrastructure, or even telephone switching equipment. Attacks could also involve remotely hijacking control systems in efforts to breach dams, impact air traffic, or shut down the power grid.[17]

Attacks launched in cyberspace could involve diverse methods of exploiting vulnerabilities in computer security: viruses, stolen passwords, insider assistance, software with secret “back doors” that intruders can penetrate undetected, and organized electronic traffic used to overwhelm computers – known as “denial of service” attacks are known to have occurred. Attacks could also involve stealing classified files, altering the content of Web pages, disseminating false information, sabotaging operations, erasing data, or threatening to divulge confidential information or system weaknesses unless a payment or political concession is made. If terrorists managed to disrupt financial markets or media broadcasts, an attack could undermine confidence or instill public panic. [18]

History of Events

Like other governments and businesses across the nation, the Central Puget Sound Region relies heavily on computers and networks to conduct its normal business. Some local examples include an attack of the SQL Slammer worm on January 25, 2003, which rendered the police computer-aided dispatch system of a Seattle suburb inoperable for several hours and stopped some bank ATM networks nationwide. Also, in August 2003, the MSBlaster and Nachi worms compromised Windows computers worldwide, including many within the City of Seattle government. [19]

Some attacks are conducted to further political and social objectives, as the following events illustrate:

- In 1996, a computer hacker allegedly associated with the White Supremacist movement temporarily disabled a Massachusetts ISP and damaged part of the ISP's record keeping system. The ISP had attempted to stop the hacker from sending out worldwide racist messages under the ISP's name. The hacker signed off with the threat, "you have yet to see true electronic terrorism. This is a promise." [20]

- In 1998, Spanish protestors bombarded the Institute for Global Communications (IGC) with thousands of bogus e-mail messages. E-mail was tied up and undeliverable to the ISP's users, and support lines were tied up with people who couldn't get their mail. Protestors spammed IGC staff and member accounts, clogged their Web page with bogus credit card orders, and threatened to employ the same tactics against organizations using IGC services. They demanded that IGC stop hosting the Web site for the Euskal Herria Journal, a New York-based publication supporting Basque independence. Protestors said IGC supported terrorism because a section on the Web pages contained materials on the terrorist group ETA, which claimed responsibility for assassinations of Spanish political and security officials, and attacks on military installations. IGC finally relented and pulled the site. [21]

- In 1998, ethnic Tamil guerrillas swamped Sri Lankan embassies with 800 e-mails a day over a two-week period. The messages read "We are the Internet Black Tigers and we're doing this to disrupt your communications." Intelligence authorities characterized it as the first known attack by terrorists against a country's computer systems. [22]

- During the Kosovo conflict in 1999, NATO computers were blasted with e-mail bombs and hit with denial-of-service attacks by hacktivists protesting the NATO bombings. In addition, according to reports, businesses, public organizations, and academic institutes received highly politicized virus-laden e-mails from a range of Eastern European countries. Web defacements were also common. Also, after the Chinese Embassy was accidentally bombed in Belgrade, Chinese hacktivists posted messages such as "We won't stop attacking until the war stops!" on U.S. government Web sites. [23]

- Since December 1997, the Electronic Disturbance Theater (EDT) has been conducting Web sit-ins against various sites in support of the Mexican Zapatistas. At a designated time, thousands of protestors point their browsers to a target site using software that floods the target with rapid and repeated download requests. EDT's software has also been used by animal rights groups against organizations said to abuse animals. Electrohippies, another group of hacktivists, conducted Web sit-ins against the WTO when they met in Seattle in late 1999. These sit-ins all require mass participation to have much effect, and thus are more suited to use by activists than by terrorists. [24]

While the above incidents were motivated by political and social reasons, whether they were sufficiently harmful or frightening to be classified as cyberterrorism is unknown as no attack thus far has led to violence or injury to persons, although some may have wreaked intimidation or inconvenience.[25]

Past Mitigation Efforts

Mitigation efforts against the threat of cyberterrorism are being addressed in trainings, workshops, and exercises taking place in the Central Puget Region and in national and global forums. Locally, the Pacific NorthWest Economic Region (PNWR) is convening scenario training on cyberterror for public and private entities. Exercises like "Blue Cascades" strive to harden infrastructure against potential attacks by examining vulnerabilities to our electrical, water, financial, and other computerized systems.[26] Per the recommendations of this exercise, a Cyber Security Council was formed to help lend advice on the direction of cyber security efforts in the region.[27]

Further efforts against cyberterror include the dedication and collaboration of public and private organizations in achieving cohesive and updated internet and network security applications. Like any mitigation effort against terrorism, organizations guarding against cyber attacks must remain vigilant and informed.

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[10] Terrorism Questions and Answers, Council on Foreign Relations, http://www.terrorismanswers.org/terrorism/cyberterrorism.html
[11] Terrorism Questions and Answers, Council on Foreign Relations, http://www.terrorismanswers.org/terrorism/cyberterrorism.html
[12] http://emd.wa.gov/3-map/a-p/hiva/25-hiva-th-terrorism.htm
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[15] "Cyberterrorism" by Dorothy Denning, Georgetown University; Testimony before the Special Oversight Panel on Terrorism Committee on Armed Services U.S. House of Representatives, May 23, 2000, http://www.cs.georgetown.edu/~denning/infosec/cyberterror.html
[16] City of Seattle Office of Emergency Management, Terrorism; http://www.seattle.gov/emergency/hazards/terrorism.htm

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[19]"Cyberterrorism" by Dorothy Denning, Georgetown University; Testimony before the Special Oversight Panel on Terrorism Committee on Armed Services U.S. House of Representatives, May 23, 2000, http://www.cs.georgetown.edu/~denning/inosec/cyberterror.html
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Dam / Dam Safety

New section in 2009

Introduction

As of the writing of this portion of the Regional Hazard Mitigation Plan (early October 2009), the data contained in this section was current. It should be understood, however, that the Howard Hanson Dam issue was evolving as this document was created. As such, information was changing daily, and the data contained in this section may no longer be correct or valid. Individuals should not rely on this data, but should view it as a demonstration of a summary of **potential** impacts. Anyone seeking current information should check with the Army Corps of Engineers directly.

In Washington State, dam safety concerns were part of the normal water-rights duties in the state departments of Conservation and Development of Water Resources. In 1970, dam safety regulations were transferred to newly-created State Department of Ecology. In the early 1980s, a separate Dam Safety Program was formed to concentrate on dam issues, primarily in response to the National Dam Safety Act in 1977. In 1980, Ecology's Dam Safety Office was reorganized and initiated its first long-range planning for improving dam security in Washington. To reasonably secure the safety of human life and property, Ecology also conducts inspections of existing dams to assure proper operation and maintenance for 994 of the 1121 dams inventoried across the state. [1]

The King County Flood Control District was formed by King County Ordinance 15728 in April 2007. [2] More information on this is located in Section 3, Regional Profile, of this Plan, under Flood Control District and Flood Warning Center, and their association and relationship.

For the 2009 Plan update, the King County Flood Control District has provided a very detailed assessment and risk analysis of six major river basins in King County and is located in Section 6 of this Regional Hazard Mitigation Plan. This detailed documentation includes land use, structures, estimating potential losses, development trends, and repetitive loss properties, as available. [2, 2.5]

The Howard Hanson Dam and subsequent increased risk of Green River flooding impacts downstream will be the main focus of this plan section.

High Probability Low Impact	**High Probability Moderate Impact**	**High Probability High Impact**
Moderate Probability Low Impact	**Moderate Probability Moderate Impact**	**Moderate Probability High Impact**
Low Probability Low Impact	**Low Probability Moderate Impact**	**Low Probability High Impact**

Dam / Dam Safety Probability and Dam / Dam Safety Impacts

Hazard Identification

There are 122 dams in King County, or 10.90% of the 1121 dams in the state. Not all of the dams have oversight from the State Department of Ecology such as the United State Army Corps of Engineers (USACE) managed Howard A. Hanson Dam exempted from Washington State regulation by WAC173-175-020. [1]

Howard A. Hanson Dam is a U.S. Army Corps of Engineers flood control dam located near the headwaters of the Green River in King County. Its primary purpose is flood control in the winter and fish enhancement in the summer. Because the dam is located in a closed watershed, public access is not permitted. [3]

The Howard Hanson Dam has been categorized in the July 2009 State Ecology's "Inventory of Dams" publication as 1A – High Risk, for downstream hazard class IF the dam were to fail and release the reservoir. [1] The dam is not in immediate danger of failing, but there is an increased risk to the downstream communities. [3]

The 2009 Green River flooding hazard is addressed with more likelihood of occurring or presents a significant impact if it does. Serious flooding may occur in some areas of King County this 2009 winter, and for the next three to five years until the Howard Hanson repairs are made. Homes, farms and businesses in the Green River Valley are particularly at risk. [3]

King County has four major dams that would cause a countywide emergency IF they should fail. These dams are located on the Tolt, Cedar, White, and Green rivers. Certain areas of King County would also be adversely affected by failures of the White River Project located in Pierce County or the Jackson Project located in Snohomish County. Additionally, localized problems could occur if one of the minor dams in the county failed. [5]

Many of the County's levees were constructed by farmers more than 40 years ago to protect their fields. Now these facilities protect homes, businesses, and

critical public infrastructure such as utilities and transportation corridors that support the region's economic prosperity. 6

History of Events

An in-depth write up on the King County Flood Control District can be located in Section 3, and the associated Flood Warning Center detailed information is included in Section 5, Flooding, Past / Present Mitigation.

Howard A. Hanson Dam

The Howard A. Hanson Dam is the primary focus of this dam hazard section at this writing in September 2009.

The U.S. Army Corps of Engineers (USACE) has discovered damage to a portion of the Howard Hanson Dam in early 2009. This dam has controlled flooding in the Green River Valley since 1962, for nearly 50 years. However the dam will only operate at 30% capacity this winter, 2009, and possibly for an additional 3-5 years. Therefore, there is a much greater risk of significant flooding during periods of heavy rain throughout the lower Green River Valley, affecting the cities of Auburn, Kent, Renton, Tukwila, and south Seattle and surrounding infrastructure. 5.5

The U.S. Army Corps of Engineers is in the process of evaluating two depressions and seepage issues -- discovered following the January 2009 floods -- on the right abutment adjacent to the Corps' Howard Hanson Dam, which provides flood risk reduction and water storage on the Green River. Until investigations and cumulative assessments can be completed, the Corps of Engineers determined it would be prudent to lower the maximum pool level for flood storage from a reservoir elevation of 1,206 feet above sea level to a lower level. Howard Hanson Dam presents no immediate danger of catastrophic failure to people and property below the dam. However, risk of flooding for those living in the Green River Valley is higher until operational capacity can be raised. 3

USACE is actively testing and investigating the source of the problems and trying to identify solutions. The USACE has significantly reduced the water storage levels at the Dam and is taking a number of steps to try and minimize the flood risk. However, the USACE does not anticipate a full solution to the problems with the Dam by this flood season. 5.5

An established Green River Flood Control Zone District, which is separate from King County Government, a King County Flood Warning System, and the King County Flood Warning Center all working towards the upcoming flood season. The cities of Auburn, Kent, Renton, Tukwila, Seattle, King County government agencies, and many others are also working closely with the USACE to prepare for the 2009 flood season. 5.5

The USACE has advised King County and cities in the Green River Valley that the dam cannot operate at full capacity and to prepare for possible flooding if water into the Howard Hanson Dam exceeds 12,000 cubic feet per second. Flows in the river reached above that level 15 times between 1932 and 1962 when the dam started operating. Calculations estimate flows would have exceeded that level 17-20 times since 1962 without the dam. 7

The USACE has placed restrictions on the pool (water) elevation and will continuously reassess the pool restrictions as conditions change. While the dam is not in immediate danger of failing, there is an increased risk to the downstream communities. 3

Should a major flood event occur with the temporary restrictions on the pool level for flood storage, it is possible that levees in the lower valley could be overtopped. The Corps will continuously reassess the pool restriction as conditions change and may raise or change the restriction on pool elevation after careful deliberation. 3

Hazard Impacts

Higher risk to the Howard Hanson Dam is due to water seeping more rapidly through an earthen bank next to the dam after record high water last winter, January 2009. Until the U.S. Army Corps of Engineers (Corps) can make repairs, it must limit the amount of flood water it stores behind the dam. 4

If heavy and prolonged rain occurs this flood season (roughly October through March 2009 - 2010), many homes and businesses in the valley that don't typically see flood water--including parts of Auburn, Kent, Renton, South Seattle and Tukwila--could be flooded. 4

Since January, the Corps' Seattle District has been working in partnership with King County and the cities in the Green River Valley to warn residents and businesses of the increased risk for downstream flooding due to decreased water holding capacity at Howard Hanson Dam. Residents, businesses and farms below the Howard Hanson Dam in the Green River Valley are being asked to prepare now for a higher risk of flooding. 4

Evacuations in some communities are possible and preparedness planning is on-going. Key transportation routes and transit service could be disrupted, vehicles and buses could be damaged, and power outages and sewage back-ups are possible even outside the immediate flood zone. 6

Major flood disasters can also destroy critical communications and public safety infrastructure and strain police, fire, and medical services throughout the entire region. 6

Economic Impacts

The economic impacts to urban areas during a potential Green River Valley flooding are high. 6,7

According to the independent analysis, prepared by ECONorthwest, Inc., the Pacific Northwest's largest economics consulting firm, one third of the county's aerospace employment is located in the floodplains. Overall, one fifth of King County's total manufacturing employment lies within floodplains, primarily in and around the cities of Auburn, Kent and Renton. 6,7

The study also noted that while only 2 percent of King County's population lives in the floodplain, roughly 6 percent of the county's jobs are located within floodplains, or 65,000 jobs with wage and salary income of $3.7 billion. Property in King County's floodplains is valued at more than $7 billion. 6,7

Expert economists are predicting that a shutdown of economic activity in King County's floodplains would cost the region $46 million or more every day, and could curtail everything from aircraft manufacturing to bustling warehouse distribution centers. 8

The $46 million figure does not include the loss of economic output from businesses that are located outside the floodplains that rely on goods and services produced by businesses inside floodplain areas, or the value of damaged or destroyed property or equipment. The $46 million in lost economic output for every day of flooding is a conservative estimate. 6,7

While it is estimated the Green River Valley generates almost $46 million of economic activity per day, and a major flood could cause up to $3 billion in damages. Approximately 26,000 residents and 3000 businesses would have to be evacuated from the lower Valley and several hundred more who live in the unincorporated upper Green River Valley if a flood is anticipated. 6,7

Past / Present Mitigation Efforts

King County created a King County Flood Control District (Ordinance No. 15728) in April 2007. The Flood Control District has an association with the Flood Warning Center, and is referenced in the Plan as stated above. [8]

Howard A. Hanson Dam, specific mitigation efforts in 2009

The Flood Control District completed repairs to 9,300 linear feet of Green River levees at five high-priority points in 2008. In partnership with the Army Corps, it is currently completing repairs to 2,200 linear feet of levees in Kent and two low spots near Auburn. The District is preparing to replace 18,000 linear feet of levees at 14 sites along the Green River in 2010. [7]

The King County Executive has requested in mid-September 2009 $8.4 million to temporarily increase the height of Green River levees and for other items to increase flood fighting capabilities. [7]

Additionally, in mid-September 2009, the King County Executive has requested more than $32 million to plan and provide for continuity of regional services such as Superior Court, elections, animal control, wastewater treatment and public health. This amount will also help protect county facilities such as the Maleng Regional Justice Center, the South Wastewater Treatment Plant in Renton and the Black River Pump Station. [7]

The U.S. Army Corps of Engineers announced by Press Release on September 22, 2009 that it will purchase and pre-position flood fighting supplies and materials for the Green River Valley in preparation of the upcoming flood season. [4]

The U. S. Army Corps of Engineers is constructing a grout curtain within the abutment of the dam to reduce seepage through a critical area of concern, as well as performing drainage improvement work to route water into the drainage tunnel. Work is expected to be done by Nov. 1, 2009. [4]
The USACE, Seattle District, will continue to evaluate reservoir operations at Howard Hanson Dam to reduce downstream flows as interim risk reduction work is completed and tested. [4]

The U. S. Army Corps of Engineers will support and augment state and local efforts to include: [4]

- Purchase approximately 400,000 sand bags and 45,000 lineal feet of expedient flood barrier products.
- Pre-position flood fighting materials within the Seattle District and make them available for loan to protect river levees and ensure that these materials are available if further flooding occurs, well in advance of flood conditions.

- Continue to provide technical assistance to the state and local agencies, including continuous review of flood risk, identification of additional actions based on changing field conditions, and advice and/or recommendations for the proposed secondary protection measures.
- Work with U.S. Geological Survey and the National Weather Service to investigate immediate improvements of early flood warning systems. 4

The U. S. Army Corps of Engineers will continue to work with the State of Washington, King County and their Congressional Delegation to look at additional options to assist Green River Valley. "The Corps is committed to ensuring safety of the Green River Valley residents." **4**

The USACE has placed restrictions on the pool (water) elevation and will continuously reassess the pool restrictions as conditions change. The dam is not in immediate danger of failing, there is an increased risk to the down stream communities. **3**

Should a major flood event occur with the temporary restrictions on the pool level for flood storage, it is possible that levees in the lower valley could be overtopped. The Corps will continuously reassess the pool restriction as conditions change and may raise or change the restriction on pool elevation after careful deliberation. **3**

Dam / Dam Safety Endnotes:

[1] State Department of Ecology, Water Resources Program, Dam Safety Section, *Inventory of Dams in the State of Washington,* July 2009, Publication #94-16, http://www.ecy.wa.gov/pubs/94016.pdf

2
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3 U. S. Army Corps of Engineers (USACE), USACE website, 909, http://www.nws.usace.army.mil/

4 U. S. Army Corps of Engineers (USACE) Seattle District Press Release, Casondra Brewster, Public Affairs Specialist, September 22, 2009, http://www.nws.usace.army.mil/

5 King County Office of Emergency Management, Hazards and Disasters, website http://www.kingcounty.gov/safety/prepare/residents_business/Hazards_Disasters/DamFailures.aspx

5.5 Public Health Seattle & King County (PHSKC) September 3, 2009, Bulletin http://www.kingcounty.gov/healthservices/health/preparedness/greenriverbasin.aspx

6 *Economic Connections Between the King County Floodplains and the Greater King County Economy*, Prepared for King County Water and Land Resources Division, ECONorthwest, October 2007,

http://www.kingcounty.gov/environment/dnrp/newsroom/newsreleases/2007/october/1024Floodplains.aspx
7 King County website, King County Executive News, September 17, 2009
http://www.kingcounty.gov/exec/news/release/2009/September/14GovFloodEvent.aspx
8 King County website, King County Natural Resources and Parks, October 24, 2007
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Lots more information is available on the USACE, King County, KC Flood Control District websites and others listed above about Howard Hanson Dam and the Green River Valley potential flooding.